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Jakob E. Lange (1864–1941).

MYCOLOGIA

OFFICIAL ORGAN OF THE MYCOLOGICAL SOCIETY OF AMERICA

VOL. XXXIX JANUARY–FEBRUARY, 1947 No. 1

JAKOB E. LANGE

1864–1941

A. A. PEARSON

The fifth and last volume of Jakob E. Lange's *Flora Agaricina Danica* has now reached us. It was completed early in 1939 and published at Copenhagen during 1940. We also have received the sad news that the author of this fine work died rather suddenly after a few weeks illness on the 27th December 1941, while the German Army still occupied his country. Later the Germans made the Smallholders School near Odense, over which he presided for so many years, the headquarters of the Gestapo. This was the building that was so neatly picked out by the British Royal Air Force and sent to smithereens. Lange with a heavy heart and a wry smile would have approved, for he hated all that the Nazis stood for.

The last volume of his work, which we now peruse with so much satisfaction, completed an undertaking started by him in 1914 when he published in the *Dansk Botanisk Arkiv* the first of a series which he called "Studies in the Agarics of Denmark." The original purpose was to give accurate microscopic details of the agarics. Altogether, twelve of these "Studies" appeared, some with a colored plate. The last was issued in 1938.

Meanwhile he had received from his countrymen enough support to print the colored drawings which were on view at the Museum of the Botanic Garden, Copenhagen. Vol. I was printed

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in 1935 followed at regular intervals by others until the war drew a curtain between us and the author.

Jakob E. Lange was born on the 2 of April, 1864. He was the son of a clergyman living in the southern part of Jutland. The Germans, at the time, were in occupation of that part of the country. In the eighties he worked as a gardener and spent some time at Kew and Paris. After getting his degree from the Danish Agricultural College, he became a teacher in the college where he remained for 30 years teaching young farmers botany and social economics. He wrote books on botany and chemistry and in 1917 took over the direction of the Smallholders School, where small farmers sent their sons and daughters for a short course on agriculture and other subjects. Lange was also prominent in the social and political movements, being at one time a leader of the Danish liberal and radical party. In the midst of these activities he found time to write a popular illustrated book on wild flowers designed for children, which had a sale of nearly 200,000 copies, and he also wrote some popular books on social economics.

But his main interest, apart from his professional activities, was the study of the agarics. Some of his early paintings are dated 1893. His first paper in 1914 dealt with the genus *Mycena* and his division of the species into two groups based on their cystidia was a new approach to the subject which put the study of this genus on a sound basis. Von Höhnel in 1913 had published in Vienna something much on the same lines though in a less practical manner, but it would not appear that Lange had any knowledge of this paper at the time. However Von Höhnel was too busy with other groups of fungi and Lange's paper remained the standard work until Kühner gave us his masterly book on the genus *Mycena* in 1938. The subsequent papers of Lange were not of equal importance but have proved of great assistance to agaricologists, especially in the study of *Coprinus, Lepiota, Psalliota, Psathyra,* etc.

It was due to a short notice on the *Mycena* paper that the writer of the present review came into contact with Lange, and carried on a correspondence with him for more than twenty years. He used to send me his manuscript and our letters mostly dealt with points of English idiom as applied to scientific papers and were often very diverting. Lange had a good command of the English language and though he inevitably went wrong on minor points, his style was clear and concise. English speaking mycologists have every reason to be grateful for his adoption of English for his work on the Agarics. In dealing with his manuscript all that was necessary was to make occasional alterations in the twist of a sentence or the use of a word contrary to English, though not always, perhaps, to American usage. A good instance was the use of the word "sordid." In a diagnosis this word would be used to indicate color and Lange wanted to make frequent use of it in spite of the view that most English writers would maintain that it can only be used in a non-material sense. You can say a man has a sordid mind, but not a sordid nose or a sordid handkerchief! However, the best American dictionaries sanction its use in the manner employed by Lange.

Lange's views on classification were on the whole conservative, and he rarely departed from the Friesian taxonomy. The new outlook of the French mycologists did not appeal to him. It is true he adopted Quélet's *Rhodophyllus* for all the species with pink angular spores, but he retained the Friesian sub-divisions, so made no real change. He followed Ricken in adopting the three Friesian sections of *Hygrophorus* as separate genera, which however he based on the structure of the gill trama. He rarely introduced a new genus. *Paxillopsis,* which he used for a rather heterogeneous group of agarics with salmon colored spores, was not a happy venture. On the other hand he described many new species in the European fungus flora—over sixty without counting new varieties and forms. Some of these have since been found outside Denmark and a few inevitably have been identified with other species, but Lange was not an irresponsible species maker and most of his newly named agarics will be found to be valid. Latin diagnoses of new species together with a general index have been issued separately for binding with the last volume.

The colored plates which adorn the five volumes of the *Flora Agaricina Danica* are a great achievement both for the author and the printer. Lange recommended using a reading lens when examining the figures. The only criticism some of us would make is that the colors might be brighter. Lange erred on the side of delicacy in this respect, but these paintings are good and together with the keys for each genus, are most useful in helping to run down a species. Of course the fungi were found in a relatively small area of Europe—in a country where trees are grown for their timber and the woods kept clear—in fact not at all the sort of paradise the mycologist dreams of, yet over a thousand species and many varieties and forms are illustrated. That is a very substantial proportion of the agarics to be found in Europe.

Lange came three times to the United States. The first occasion was in 1927 when he had little opportunity of looking at the fungi. In 1932 the second trip was made, and on that occasion he did a lot of collecting and wrote a short account of his impressions of the North American Fungus Flora which appeared in Vol. 26, p. 1–12 of *Mycologia*. It was here he made the remarkable statement that about 70 per cent of the species he met with could be identified with European species familiar to him.[1] The last American journey was in August 1939. He got home safely but the more extensive comparative study of the European and American agarics was not to come from his pen.

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[1] When collecting in the Great Smoky Mts. National Park in 1939 he stated that although he recognized 70 per cent of the species he met in the Adirondacks as fungi which occurred in Europe, he did not know more than 30 per cent of those seen in the "Smokies."—Editor.

A NEMATODE-STRANGLING DACTYLELLA WITH BROAD QUADRISEPTATE CONIDIA

CHARLES DRECHSLER[1]

(WITH 2 FIGURES)

In earlier papers I have described under the binomials *Trichothecium polybrochum* (**6**: 535–538), *Arthrobotrys dactyloides* (**6**: 482–487), *Dactylella doedycoides* (**8**: 448–456), *Dactylella heterospora* (**9**: 339–349), *Dactylella bembicodes* (**6**: 487–492), and *Dactylaria brochopaga* (**6**: 514–518) six species of clampless nematode-capturing hyphomycetes which among predaceous fungi are especially remarkable through their utilization of stout hyphal rings by whose forcible contraction the prey is not only held securely but is at the same time strangled so severely that disablement soon follows, permitting early intrusion of assimilative filaments into the fleshy body. From resemblances in mycelium and asexual reproductive parts it is obvious that these species are closely related to one another as well as to a greater number of other clampless hyphomycetes likewise subsisting by capture of eelworms but using predaceous devices not operating in any large measure through constriction. To the same taxonomic kinship are manifestly referable also several forms that prey on amoebae (**4**), testaceous rhizopods (**3**, **5**, **7**), or insects (**11**). The predaceous apparatus employed by these forms in no instance operates by strangulation. Attack by strangulation is likewise wholly unknown in either of the two mainly terrestrial series of animal-capturing fungi taxonomically alien to the clampless hyphomycetes; such forcible attack not having come to light in the two nematode-capturing species of the clamp-bearing genus *Nematoctonus* (**13**), nor among the many predaceous members of the Zoöpagaceae, four of which are known to prey habitually on nematodes (12). Like the predaceous members of *Nematoctonus* and of the Zoöpagaceae the rotifer-capturing saprolegniaceous form *Sommerstorffia spinosa* Arn. (1) employs only adhesive organs in taking prey. However, occasional strangulation of rotifers in the constricting rings of *Dactylella bembicodes* has been recorded by both Couch (2: 309; pl. 27, fig. 14) and myself (6: 487, 488, 491, 492; 537, fig. 18, *N*); and subsequently I have observed rotifers captured also in the constricting rings of *Arthrobotrys dactyloides* and *Dactylaria brochopaga.*

---

[1] Pathologist, Division of Fruit and Vegetable Crops and Diseases, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration, United States Department of Agriculture; Plant Industry Station, Beltsville, Maryland.

A seventh species intimately akin to the six enumerated above, and displaying the same astonishing manner of capturing motile eelworms, recently made its appearance in a maizemeal-agar plate culture which after being permeated with mycelium of *Pythium arrhenomanes* Drechsl. had been further planted with a small quantity of friable leaf mold kindly supplied by R. K. Zuck, who gathered it from the floor of a beech (*Fagus grandifolia* Ehrh.) wood near Webster, N. Y., on September 20, 1945. The fungus was first noted 28 days after the forest detritus had been added. As the predaceous mycelium at the time extended scarcely 10 mm. out from the deposit of opaque material its development into the transparent agar could hardly have begun more than three or four days earlier. Considerable delay in extensive development could well have been occasioned by the originally hard consistency of the agar medium. Owing to this firm consistency movement of eelworms under the surface of the culture was naturally repressed until prolonged bacterial action had brought about noticeable softening; and until subsurface movement of prey took place freely the constricting rings of the new fungus, which like those of the six species previously described are commonly produced in submerged positions (FIG. 1, *A; B, a*), could have had only meager opportunity for effective operation. Whenever the fungus was transplanted to fairly soft agar cultures abundantly infested with eelworms, it has always been prompt in extending its predaceous mycelium in all directions.

The constricting rings of the New York fungus bear a close general resemblance to those of the six strangulating species described earlier. They are borne on relatively straight mycelial filaments

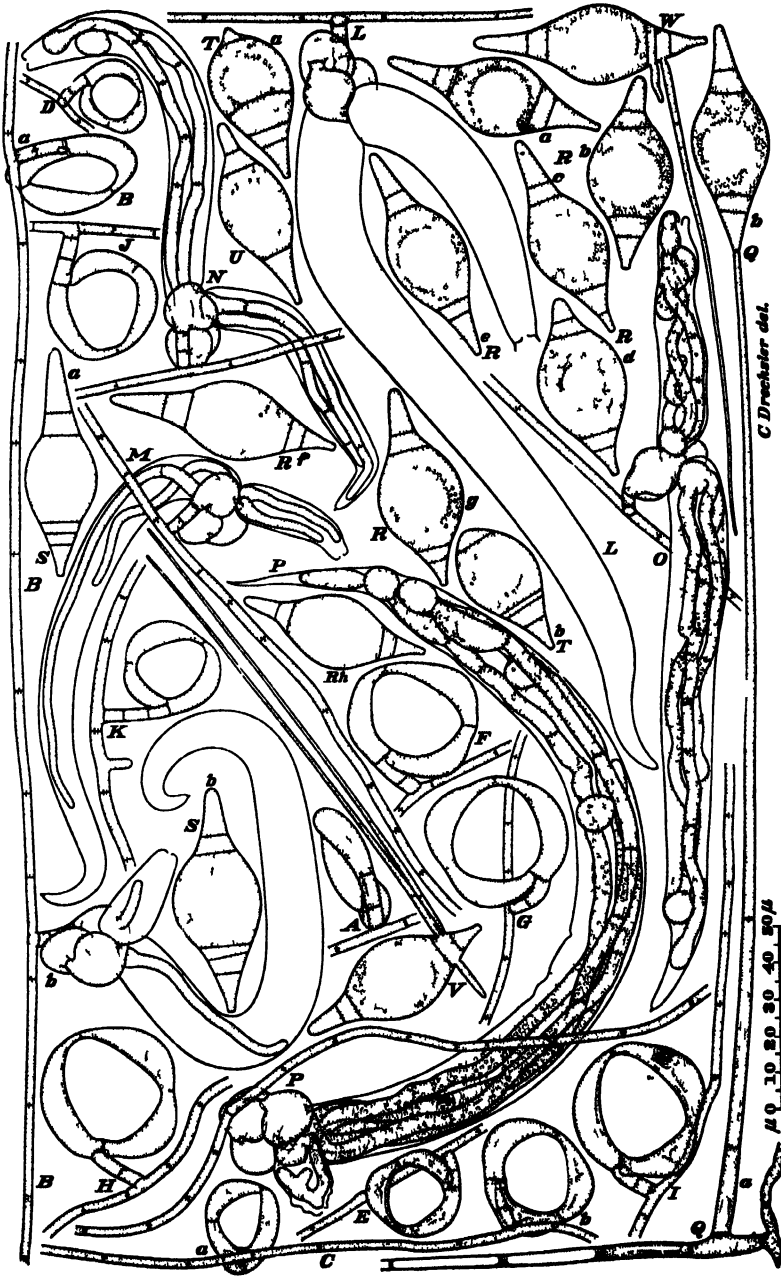

FIG 1 *Dactylella coelobrocha.*

at intervals varying commonly from 25 μ (FIG. 1, *C, a, b;* FIG. 2, *A, a, b*) to more than 200 μ (FIG. 1, *B, a, b*). They are formed usually in a plane making a right angle with the parent filament (FIG. 1, *A; B, a*), and consequently in their original posture are usually seen edgewise or nearly edgewise. However, many of them later come to be directed flatwise to the observer, mainly from being jostled sideways by largish specimens of the nematodes they are designed to capture; and these displaced examples then more advantageously reveal the arrangement of their component cells. They are attached to the parent filament by a sturdy, usually two-celled stalk (FIG. 1, *C, a, b; D–J;* FIG. 2, *A, a, b; B–F*), and are made up regularly of three arcuate segments; the distal arcuate segment, as a rule, being fused both to the distal end of the second stalk cell and to the proximal end of the first arcuate segment (FIG. 1, *C, a, b; D–I; K;* FIG. 2, *A, a, b; B–F*). In somewhat exceptional instances the third arcuate segment may be anastomosed only with the second stalk cell (FIG. 1, *J*); or, again, the stalk may consist of three cylindrical cells (FIG. 1, *K*). The rings vary considerably with respect to size; the aperture in the smaller ones sometimes measuring only 12 μ across (FIG. 1, *D*), whereas in the larger ones it may measure 29 μ or 30 μ in greatest width (FIG. 1, *H*). Closure of the ring is accomplished, much as in rings of the six allied species, through contraction and centripetal swelling of the three arcuate cells (FIG. 2, *G*).

Despite their general resemblance to the rings of other species the predaceous organs of the New York fungus offer some modifications distinctive enough to merit attention. On the whole their component segments display somewhat more pronounced median thickening than the arcuate segments in allied forms. Further, the inner contour of the ring usually shows more pronounced curvature near the ends of the constituent cells than in their middle portions; so that the aperture here tends rather more strongly toward a rounded triangular outline than in other species. Yet, though the middle portion of the cell may show only slight curvature along the inner contour of the ring, it commonly lacks the curious median bulge whereby the aperture, particularly in rings of *Dactylella doedycoides* and *D. heterospora,* is given a scalloped outline suggestive, for example, of the trefoil ornamentation used

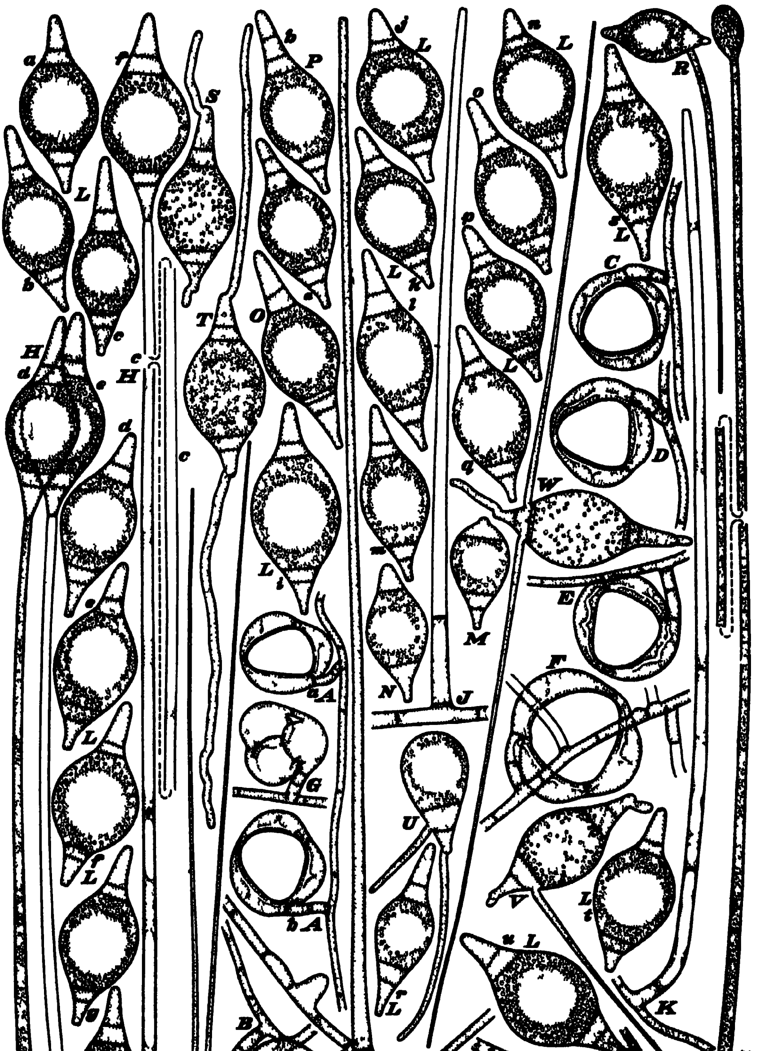

FIG 2 *Dactylella coelobrocha*

in architecture. In the present species, it is true, some perceptible modification in the outline of the aperture is often brought about by a slight bulging of the anastomosing connection between the proximal and distal arcuate segments. However, neither this connection nor the commonplace septal connection between the second and third arcuate cells shows much that could be held especially distinctive of the species. But the connection between the proximal and median arcuate cells presents marked peculiarity in narrowing to a width of 1.5 to 2.5 μ—to a width, therefore, often scarcely equivalent to one-third or one-fourth of the greatest width of the arcuate cells in question. Usually the narrowing of the two cells toward the septum dividing them is somewhat gradual, so that the connection often appears as a slender isthmus several microns long. In young predaceous organs capable of functioning vigorously the cross-wall in such an isthmus is often not clearly visible; the portion of the septum near the inner contour of the ring, together with the cell wall bordering the aperture, being, as a rule, wholly indiscernible to ordinary microscopical scrutiny. For that matter the other two transverse partitions in the ring likewise frequently fade from view in proximity to the inner contour, and even in proximity to the outer contour stand out less distinctly than the homologous partitions in related forms.

Since in predaceous organs that have closed, and in organs too old to function effectively, the cell membrane bounding the aperture, as also the cross-walls, appears much as in the similar organs of allied forms, there is reason to presume that the poor visibility of these membranous parts derives less from physical characteristics proper to them than from unusually dense consistency of the protoplasm in contact with them. The appearance of the bordering protoplasm, certainly, is suggestive of exceptional density. Besides, whereas the ring segments in the several other species are generally found occupied throughout with protoplasm of rather homogeneous aspect, in the New York fungus they show what would seem to be a narrow elongated vacuole extending longitudinally through them for nearly their entire length. When the open ring is viewed flatwise this vacuole is most often seen following a course more or less parallel to the concave boundary of the arcuate segment, usually at a distance of 1 to 2 μ from that boundary. Over most of its length the vacuole commonly maintains a width of about 1 μ, but near the middle of the segment it usually widens out markedly in extending a wedge-shaped arm toward the outer contour of the ring (FIG. 1, *C, a, b; E; I; J;* FIG. 2, *A, a, b; C; F*), and in many segments the vacuole has two or three such arms (FIG. 1, *F–H;* FIG. 2, *B*). Occasionally the vacuole follows a more crooked course and then may in places lie nearly midway between the inner and outer boundaries of the ring segment (FIG. 1, *K;* FIG. 2, *E*). In segments where the vacuole occupies its more usual position, the denser protoplasm that tends to make membranous structures appear indistinct is localized especially in the narrow layer bordering the inner contour of the ring. After closure of the ring the swollen segments each reveal a large spherical vacuole (FIG. 1, *B, b; L–P;* FIG. 2, *G*) which could well have been formed from the elongated vacuole present earlier. However, as in the six allied species the swollen segments show similar internal organization, it is not evident that the elongate vacuole in the New York fungus causes any distinctive modification in the arrangement of cell contents after contraction has taken place.

The narrowed cord-like connection between the first and second arcuate segments makes for a curious modification in the operation of the predaceous organ. While in the six other strangulating species all three cells composing the ring press their broadened bulk directly into the animal's body and thus squeeze it with about equal violence from three sides, in the New York fungus the captured nematode is usually found gripped only by the first two cells, which in their swollen condition are interposed between the captive and the distal cell. As a rule the swollen portions of the first and second cells seem less deeply indented into the animal's body than are the three swollen cells of allied forms; strangulation here evidently being brought about for the most part through deep narrow indentation of the fleshy body by the slender cord-like connection. Manifestly the slender connection serves altogether in a passive manner. The pull whereby it constricts the eelworm so severely is supplied through the contraction of all three arcuate segments, for the distal cell obviously loses little in mechanical effectiveness from lack of direct contact with the captive. Since the pressure put on one side of the animal by the swollen parts of the first and second cells is applied over a wider region than the opposing pressure exerted on the other side by their slender connection, both the forward and backward portions of the nematode are often abruptly bent away from the closed ring (FIG. 1, *B, b; L; N; P*). Consequently the captured animal, which here is commonly gripped near the periphery rather than in the center of the ring, shows more often than captives strangled by allied forms an unnatural angular posture resembling a little the posture usually taken in the hangman's noose. With this unpleasant device, indeed, the predaceous organ under consideration would seem to have some measure of real similarity.

When from increasing disablement the struggles of a captured nematode have been largely quieted, the two swollen cells directly in contact with the animal will push delicate processes through its integument into the underlying tissue; the processes after some enlargement growing lengthwise through musculature and organs (FIG. 1, *B, b; M*) until the fleshy interior is occupied from head to tail by assimilative hyphae (FIG. 1, *N–P*). Small slender eelworms measuring about 200 μ in length and 10 to 12 μ in width are usually permeated forward and backward by two such hyphae (FIG. 1, *M, N*), whereas stouter specimens measuring about 300 μ in length and 18 to 20 μ in width commonly reveal no less than four (FIG. 1, *P*). Branching of the assimilative filaments occurs, in the main, close to their origin from the swollen cells, but occasionally may also be observed in more remote positions. In most though not in all assimilative filaments the distal segment undergoes globose swelling (FIG. 1, *N*), and rather often the second cell from the tip, together at times with the third cell, likewise becomes distended in varying measure (FIG. 1, *O, P*). Similar terminal enlargement of absorptive hyphae was noted earlier in the allied strangulating species *Arthrobotrys dactyloides*. After completing their growth the assimilative filaments form additional cross-walls until they are divided into segments of only moderate length. During the period they are most active in appropriating the globuliferous degenerating contents of the animal host their protoplasm shows numerous small globules (FIG. 1, *O, P*). When the host materials approach exhaustion the hyphal contents become less and less globuliferous. Finally, after increasing vacuolization (FIG. 1, *N*), the remnants of nearly homogeneous fungus protoplasm are withdrawn from the assimilative elements by way of the swollen cells of the closed ring into the parent mycelial filament.

A tract of predaceous mycelium amply nourished through expropriation of many eelworms will usually soon put forth scattered conidial apparatus. Rather tall conidiophores, generally similar to to those of *Dactylella bembicodes,* though appreciably more slender, are produced, some in groups of two or three (FIG. 2, *H, a–c*), others singly at variable distances from their fellows (FIG. 1, *Q;* FIG. 2, *I–K*). Although the shorter conidiophores (FIG. 2, *H, a, b; J*) often measure only about 200 μ in length, the taller ones frequently attain a height of 450 μ (FIG. 2, *H, c*) and occasionally a height exceeding 500 μ In some instances they produce their usually single conidium without forming any cross-wall above the septum regularly delimiting them at the base (FIG. 2, *I*), but more often one or two additional septa are deposited proximally (FIG. 1, *Q;* FIG. 2, *H, a–c; J; K*). Production of conidia plurally, either through subterminal branching or through renewed apical elongation after development of the first spore, seems relatively infrequent. However, when conidiophores that have produced a conidium fall over on the moist substratum, they often send up individually a new conidiophore from one of their stout basal cells (FIG. 1, *Q*), while the slenderer distal portions, if not previously evacuated of contents, usually grow out vegetatively like ordinary mycelial hyphae.

The conidia of the New York fungus are of the large broad type which, though unusual among the Mucedinaceae generally, is characteristic of many nematode-capturing hyphomycetes, including, indeed, four of the six constricting species made known earlier. With respect to septation and cellular make-up they differ decisively from the conidia of any of these four strangulating forms. In strong contrast to the uniseptate condition prevalent in spores of *Trichothecium polybrochum* and to the biseptate condition most common in the large conidia of *Dactylella doedycoides* as well as of *D. heterospora,* and in fairly pronounced contrast also to the triseptate condition typical of *D. bembicodes,* they show most frequently a symmetrically quadriseptate partitioning whereby the cell in median or penultimate position greatly exceeds the others with respect to length, width, and volume (FIG. 1, *Q, b; R, a–h;* FIG. 2, *H, d–f; L, a–u*). Where abundant sporulation, accompanied by a high degree of uniformity in size and shape, gives ample assurance of normal development, 100 conidia chosen at random, whether from a nematode-infested culture or from a pure culture on maizemeal agar, are usually found to include eighty to eighty-five quadriseptate specimens whose distended middle segment is much larger than the two cells below it or than the two cells above it. In cellular make-up these quadriseptate conidia thus show similarity to the five-celled conidia of approximately equal length that predominate in the nematode-capturing hyphomycete I have referred (**6**: 492–496) to *Dactylella ellipsospora* Grove (**14**). However, whereas in this hyphomycete, which captures its prey by means of stalked adhesive knob-cells, the four smaller segments of symmetrically quadriseptate conidia differ rather little with respect to length, in the New York fungus the parabasal and penultimate segments are nearly always conspicuously shorter than the basal and apical segments. Further, the large median cell widens more pronouncedly in the New York fungus than in the knob-bearing species, giving the conidium a more strongly ventricose outline and a greater measurement in transverse diameter. The data on conidial dimensions included in the diagnosis below were derived from 100 symmetrically quadriseptate specimens taken at random in abundantly sporulating material. The 100 measurements for length, expressed in the nearest integral number of microns, showed a distribution as follows: 46 μ, 1; 47 μ, 2; 48 μ, 7; 49 μ, 3; 50 μ, 4; 51 μ, 13; 52 μ, 15; 53 μ, 8; 54 μ, 14; 55 μ, 6; 56 μ, 6; 57 μ, 4; 58 μ, 5; 59 μ, 1; 60 μ, 1; 61 μ, 4; 62 μ, 4; 63 μ, 1; 64 μ, 1; whereas the values for greatest width were distributed thus: 18 μ, 2; 19 μ, 6; 20 μ, 18; 21 μ, 40; 22 μ, 18; 23 μ, 7; 24 μ, 6; 25 μ, 3.

Among the conidia (FIG. 1, *S–U;* FIG. 2, *M–P*) not conforming to the symmetrically quadriseptate type most characteristic of the species, some are divided by five cross-walls into six cells; the additional cell appearing most often as a short segment between the short parabasal and massive antepenultimate segments (FIG. 1, *S, a, b;* FIG. 2, *O*), though occasionally it occurs in antepenultimate position directly above the massive cell (FIG. 2, *P, a, b*). More pronouncedly unsymmetrical septation is found in some quadriseptate conidia where the massive cell lies in penultimate position above three smaller proximal cells (FIG. 1, *T, a, b*). Now and then a conidium contains only three cross-walls, with the massive cell either in penultimate (FIG. 2, *M*) or in antepenultimate FIG. 1, *U*) position, but in such instances, especially where the spore is of good size, the septation observed cannot always be regarded as definitive. The scattered biseptate conidia in which the massive cell commonly occupies a median position between a small basal cell and a small apical cell (FIG. 2, *N*) likewise invite suspicion as to their maturity.

In many cultures a large proportion—sometimes virtually all—of the conidia, while still borne aloft on the erect conidiophores, will give rise, mostly from the short parabasal segment, to delicate filamentous outgrowths in numbers commonly ranging from one to three (FIG. 1, *V, W*; FIG. 2, *Q, R*). As a rule these outgrowths are mostly simple and project out at approximately right angles to the longitudinal axis of the spore, yet some of them bear proximally a branch oriented parallel to the spore axis (FIG. 2, *Q*). Though commonly only 1.8 to 2.5 μ wide at the base they taper upward in easily noticeable degree; so that in well developed specimens 125 to 200 μ long a distal portion of considerable length may measure only 0.6 to 0.8 μ in width. When left undisturbed they usually keep a conspicuously stiff straight posture despite their unusual delicateness. Whereas the shorter outgrowths most often appear continuous throughout with the conidial segment from which they arise, those of greater length frequently contain one or two cross-walls in their stouter basal portions.

When conidia with small apical and basal segments fall on a moist substratum, they soon germinate by putting forth two germ hyphae about 2.5 μ wide; one of the hyphae being extended usually from the region immediately bordering the slightly flattened base, the other from the rounded apical region (FIG. 2, *S, T*). Production of a germ hypha from the usually small parabasal segment happens only occasionally, as, for example, in instances where the large massive cell is found in terminal position (FIG. 2, *U*). The presence of one or more finely tapering outgrowths on the parabasal segment does not seem to abate the general preference for bipolar germination (FIG. 2, *V, W*). Germ tubes from fallen conidia anastomose freely with neighboring mycelial filaments (FIG. 2, *X, Y*) ; and, indeed, hyphal fusions of all sorts occur no less abundantly here than elsewhere in the series of clampless predaceous hyphomycetes. Much as in allied forms, again, conidia frequently send up a robust conidiophore whereon a secondary conidium is produced (FIG. 2, *Y*).

Emission of filamentous outgrowths from conidia that are still held aloft on the erect conidiophores is not at all infrequent among the other broad-spored nematode-capturing species of *Dactylella*, nor among the broad-spored predaceous species of *Dactylaria* such as *Dactylaria thaumasia* Drechsl. (**6**: 518–523) and *Dactylaria psychrophila* Drechsl. (**10**: 154–166). In these related species the outgrowths tend usually to intergrade more or less indistinguishably with germ hyphae and germ conidiophores. Although similar intergradation is observable likewise in the present fungus, the outgrowths here often become so distinctively differentiated that they present much the general appearance of setose appendages of the type familiar, for example, in *Alternaria Solani* (Ell. & Mart.) Sorauer.

The fungus was readily isolated by transferring conidia from erect conidiophores in nematode-infested cultures to poured plates of sterile agar medium; the transfer being accomplished conveniently by touching the tips of the conidiophores with a slice of agar held on a flamed platinum spatula. In pure culture on maizemeal agar a fairly dense submerged mycelium develops, which, owing to haphazard arrangement of the component filaments, is without the luster characteristic of *Arthrobotrys dactyloides* and *Dactylaria brochopaga* when cultivated under similar conditions. As many of the finer branches given off by the larger hyphae ramify rather extensively, the submerged mycelium offers a somewhat more delicate appearance than would seem commensurate with the fairly robust character of the conidial apparatus which after several days becomes macroscopically visible, together with interspersed aerial vegetative hyphae, as a scanty arachnoid weft.

In view of the curiously vacuolate condition of the arcuate cells making up its predaceous organs the fungus is described under a specific epithet compounded of two words meaning "hollow" and "noose," respectively.

Dactylella coelobrocha sp. nov.

Mycelium effusum; hyphis hyalinis, septatis, plerumque 1.4–5 μ crassis, hic illic ex ramulis bilocularibus (raro trilocularibus) vulgo 10–18 μ longis et 2.5–4.2 μ crassis laqueos circulares 20–40 μ latos proferentibus qui in 3 cellulis arcuatis 14–40 μ longis medio 3.5–8.5 μ crassis consistunt et foramen rotundum vel rotundo-triangulum 12–30 μ latum circumdant; cellulis in extremis fere coarctatis, copula inter primam et secundam praesertim angusta et plerumque tantum 1.5–2.5 μ crassa; quaque arcuata cellula in lato foramen juxta vacuolum elongatum habente; vermiculo nematoideo in laqueum apertum errato omnibus tribus cellulis arcuatis abrupte se contrahentibus tumentibusque, animal vulgo inter primam et secundam arripientibus, captivum copula angusta magnopere comprimentibus, id ita ad modum laquei carnificis necantibus, his duabus cellulis mox integumentum ejus perforantibus, hyphas intus evolventibus quae carnem exhauriunt; hyphis assumentibus mediocriter septatis, magnam partem 2.5–5 μ crassis sed saepius in cellulas 5–8 μ crassas abeuntibus. Hyphae fertiles incoloratae, erectae, prope basim 1–3 septatae, vulgo simplices, plerumque 200–500 μ altae, basi saepius 4–6 μ crassae, sursum leniter attenuatae, apice saepe 1.5–3 μ crassae, conidia singula ferentes, quandoque recrescentes et aliud conidium gignentibus. Conidiis incoloratis, plerumque late fusiformibus, medio valde inflatis, 2–5 septatis, saepissime 4 septis in 5 cellulas divisis tali modo ut cellula media (antepaenultima) multo grandior quam aliae sit, tum plerumque ex toto 46–64 μ (saepius circa 53.7 μ) longis et 18–25 μ (saepius circa 21.2 μ) crassis, cellula infima 5.4–13.7 μ (saepius circa 8.2 μ) longa, cellula secunda 2.6–5.7 μ (saepius circa 4.3 μ) longa, cellula media 21.4–30.8 μ (saepius circa 25.4 μ) longa. cellula paenultima 2.8–6.8 μ (saepius circa 4.5 μ) longa, cellula summa 6.7–15 μ (saepius circa 11.3 μ) longa; quandoque omnibus cellulis glabris, quandoque cellula secunda praecipue 1 usque 5 appendices filiformes ad pares angulos emittente; appendicibus incoloratis, rectis, aliquid rigidis, continuis vel prope basim 1–2 septatis, plerumque 50–200 μ longis, basi 1.8–2.5 μ crassis, sursum attenuatis, apice 0.6–0.8 μ crassis.

Vermiculos nematodeos diversos (*Plectum parvum* et species *Rhabditis* et *Wilsonematis* inter alia) capiens consumensque habitat in foliis *Fagi grandifoliae* putrescentibus prope Webster, New York.

Mycelium spreading; vegetative hyphae colorless, septate, mostly 1.4 to 5 μ wide, often especially in presence of nematodes producing mostly underneath and in perpendicular positions approximately circular rings measuring 20 to 40 μ in outside diameter and composed individually of three arcuate cells 14 to 40 μ long, 3.5 to 8.5 μ wide in the middle—the first and third of the cells regularly being united to each other as well as to the distal end of a somewhat curved two-celled (rarely three-celled) supporting stalk commonly 10 to 18 μ long and 2.5 to 4.2 μ wide; all three cells narrowing toward their delimiting septa, but the connection between the first and second being especially narrow, often measuring only 1.5 to 2.5 μ in width; each cell having an elongate vacuole, mostly near

the side bordering the ring aperture; this aperture being of circular or rounded triangular shape, and varying from 12 to 30 μ in greatest width. After entrance of a nematode into the ring aperture all three arcuate cells abruptly contracting and swelling, thereby gripping the animal usually between the first and second cells, and through deep constriction brought about mainly by strong pull on the narrow cord-like connection strangling the captive somewhat as in a hangman's noose; the two cells then perforating the integument and extending lengthwise through the animal assimilative hyphae for the most part 2.5 to 5 μ wide but often terminating in cells 5 to 8 μ wide. Conidiophores colorless, erect, containing one to three cross-walls mostly in the basal portion, usually unbranched, commonly 200 to 500 μ high, 4 to 6 μ wide at the base, tapering gradually upward, often 1.5 to 3 μ wide at the tip, there bearing a single conidium and sometimes, on renewed elongation, a second conidium. Conidia colorless, mostly broadly fusiform and strongly ventricose in the middle, containing two to five septa, but most often divided by four cross-walls into five cells in such wise that the middle dolioform cell is much larger than the others,—then mostly 46 to 64 μ (average 53.7 μ) long and 18 to 25 μ (average 21.2 μ) wide, with the basal cell measuring often 5.4 to 13.7 μ (average 8.2 μ) in length, the parabasal cell 2.6 to 5.7 μ (average 4.3 μ), the median cell 21.4 to 30.8 μ (average 25.4 μ), the penultimate cell 2.8 to 6.8 μ (average 4.5 μ), and the apical cell 6.7 to 15 μ (average 11.3 μ); appendages sometimes wholly absent, but at other times present in numbers from one to five, usually arising from the short parabasal cell at right angles to the spore axis, colorless filiform, straight, rather rigid, continuous or with one or two cross-walls in the basal portion, mostly 50 to 200 μ long, 2 to 2.5 μ wide at the base, tapering upward to a width of 0.6 to 0.8 μ in the dista portion.

Capturing and consuming nematodes of different species (*Plectus parvus*, *Rhabditis* spp., and *Wilsonema* sp. among others), i occurs in decaying leaves of *Fagus grandifolia* near Webster, N. Y

PLANT INDUSTRY STATION,
BELTSVILLE, MD.

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EXPLANATION OF FIGURES

FIG. 1. *Dactylella coelobrocha;* drawn to a uniform magnification with the aid of a camera lucida; × 500 throughout. *A,* portion of hypha bearing a predaceous ring in normal position. *B,* mycelial hypha bearing two predaceous rings, *a* and *b*; one of the rings, *a,* being open and approximately in normal position; the other ring, *b,* having closed on a specimen of *Plectus parvus* and intruded two young assimilative hyphae into its body. *C,* portion of mycelial hypha bearing two open predaceous rings, *a* and *b,* oriented flatwise. *D–I,* portions of mycelial hyphae, each bearing an open predaceous ring oriented flatwise; the several rings collectively showing usual variations in size and shape. *J,* portion of mycelial hypha with a predaceous ring oriented flatwise; the distal arcuate segment here being attached only to the distal cell of the stalk, not to the proximal arcuate segment. *K,* portion of mycelial hypha with a predaceous ring oriented flatwise; the stalk consisting of three segments. *L,* portion of mycelial hypha bearing a predaceous ring that has closed on a specimen of *Wilsonema* sp. *M,* portion of mycelial hypha bearing a predaceous ring that has closed on a specimen of *Plectus parvus;* from the ring two assimilative hyphae are growing forward, and two others are growing backward through the fleshy body. *N,* portion of hypha with a predaceous ring that has closed on a specimen of *Plectus parvus;* the two assimilative hyphae extending forward like the two others extending backward have become strongly vacuolate as the host contents approached exhaustion; the two assimilative hyphae extending forward show the expanded terminations usual for the species. *O*, portion of mycelial hypha with a predaceous ring that has closed on a specimen of *Plectus parvus;* all the longer assimilative hyphae have swollen terminations. *P*, portion of hypha with a predaceous ring that has closed on a specimen of *Rhabditis* sp.; the four assimilative hyphae extended backward in the animal terminate individually in one to three distended segments. *Q*, prostrate hypha that has given rise to an erect conidiophore, *a*, whereon is borne a quadriseptate conidium, *b*. *R*, eight quadriseptate conidia, *a–h*, of the symmetrical cellular make-up most usual for the fungus. *S*, two quinqueseptate conidia, *a* and *b*, each with its swollen antepenultimate cell placed above three small proximal cells. *T*, two quadriseptate conidia, *a* and *b*, in which the massive cell is found in penultimate position. *U*, triseptate conidium whose massive cell lies between two smaller distal cells and a smaller basal cell. *V*, conidium whose parabasal cell bears three appendages, of which two are stiff and hair-like. *W*, quinqueseptate conidium bearing a filamentous appendage on its parabasal cell and a short hyphal outgrowth on the discoid third cell.

FIG. 2. *Dactylella coelobrocha;* drawn to a uniform magnification with the aid of a camera lucida; × 500 throughout. *A*, portion of hypha bearing two open predaceous rings, *a* and *b*, which are turned flatwise. *B–F*, portions of mycelial hyphae, each with an open predaceous ring turned flatwise; the several rings collectively showing usual variations in size and shape. *G*, predaceous ring that has closed without capturing an eelworm. *H*, group of three conidiophores, *a–c*, bearing the solitary conidia *d–f*, respectively; owing to lack of space the conidiophore *c* is shown in parts whose proper continuity is indicated by broken lines. *I–K*, denuded conidiophores. *L*, twenty-one quadriseptate conidia, *a–u*, of the symmetrical cellular composition most usual for the fungus. *M*, small triseptate conidium whose largest cell lies between two small proximal cells and a small apical cell. *N*, small biseptate conidium with its massive cell in median position. *O*, quinqueseptate conidium wherein the massive antepenultimate cell is placed above three smaller proximal cells. *P*, two quinqueseptate conidia, *a* and *b*, wherein the massive cell is placed between two small proximal cells and three small distal cells. *Q*, large quinqueseptate conidium whose small parabasal cell bears two long, stiff setose appendages, one of which is branched near the base. *R*, small triseptate conidium whose parabasal cell bears a single setose outgrowth. *S*, *T*, quadriseptate conidia of symmetrical make-up, each germinating by production of a germ tube from each end. *U*, biseptate conidium which, owing to lack of a small apical cell, is putting forth a germ tube from the small parabasal cell as well as from the small basal cell. *V*, bipolar germination of a symmetrically quadriseptate conidium bearing a setose outgrowth on its small parabasal segment. *W*, bipolar germination of a symmetrically quadriseptate conidium bearing two long setose outgrowths on its small parabasal cell. *X*, conidium that has put forth a germ tube from near each of its ends, both germ tubes having very soon fused with mycelial hyphae nearby. *Y*, a fallen conidium whose apical cell has put forth a young erect conidiophore as well as a vegetative germ tube that soon anastomosed with a mycelial filament; owing to lack of space the conidiophore is shown in parts whose proper continuity is indicated by broken lines.

STUDIES IN THE GENUS INOCYBE. I. NEW AND NOTEWORTHY SPECIES FROM WASHINGTON *

D. E. Stuntz

(WITH 50 FIGURES)

The abundant and varied agaric flora of Washington includes many interesting species of the genus *Inocybe*. Some of these have not been reported from the United States before, others have not been found previously in Washington, and still others cannot be identified satisfactorily with any of the American or European species. During the course of a study of *Inocybe* which has been in progress for several years, some species in each of the above categories have been found. Twenty of these are presented in this paper. Many others are included in my collections, awaiting further study, and continued field work is expected to add to the number.

The species presented in this paper were collected during the years from 1934 to 1940. All collections have been deposited in the herbarium of the University of Washington at Seattle, Washington, and where the material permitted, portions of the types of new species have been deposited in the herbarium of the University of Michigan. Collection numbers given in parentheses after the locality are my own. The symbol (R) following a color name indicates that the name is from Ridgway, Color Standards and Color Nomenclature (12): a color name followed by a number in parentheses (*i.e.*, snuff brown (303)t.–1) is from the Répertoire de Couleurs (11). All drawings of microscopic characters were made with a camera lucida, at an initial magnification of 1720 diameters for the pleurocystidia, cheilocystidia, and sterile cells, and 3625 diameters for the spores, and reduced approximately one-half in printing. Grateful acknowledgment is made to Dr. W. M. Read of the University of Washington, for assistance in the preparation of the Latin descriptions.

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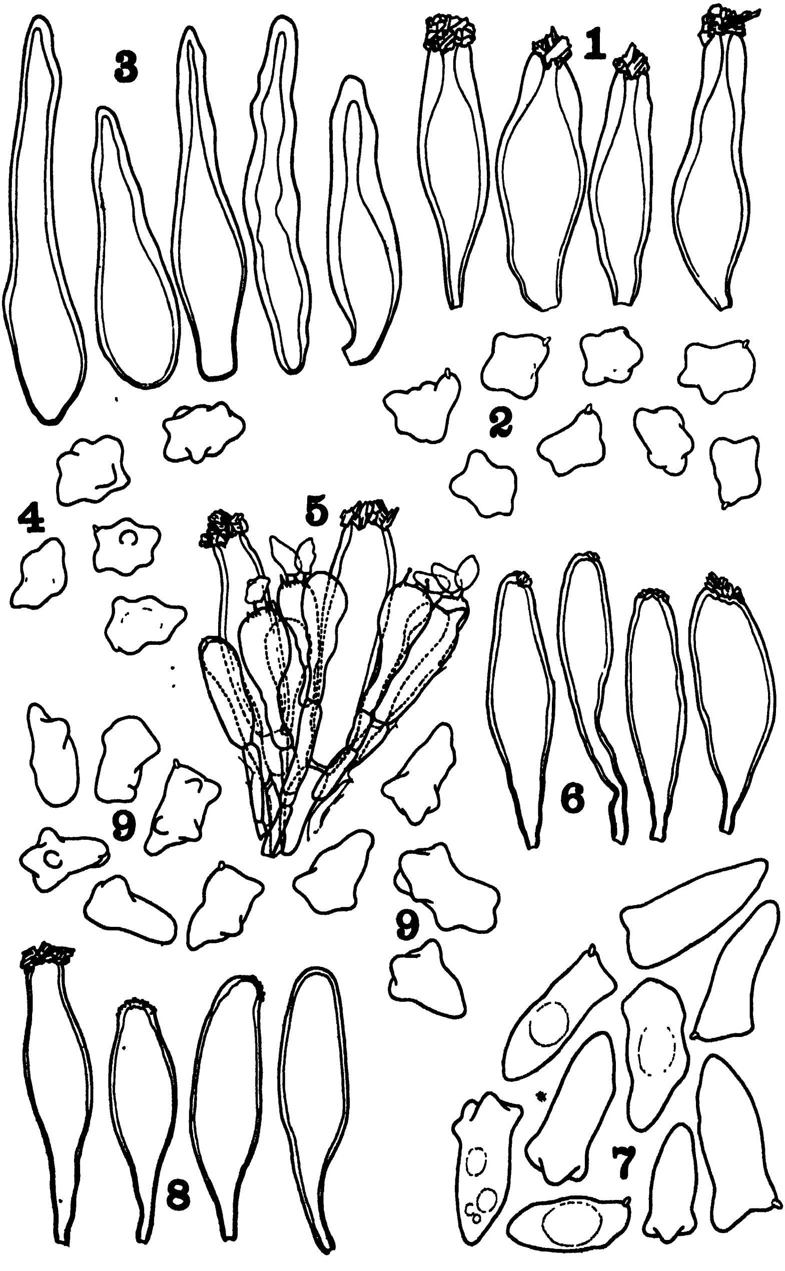
* This article is a condensation of material embodied in a dissertation presented to the faculty of the Graduate School of Yale University, in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

1. INOCYBE ALBODISCA Pk. (FIGS. 1, 2, 45)

PILEUS 2–4 cm. broad, campanulate, becoming expanded and umbonate, or remaining campanulate, margin persistently incurved, surface lubricous or subviscid when moist, soon drying subshining, smooth, glabrous, a little rimulose at the margin when mature; color white to ivory or cream colored at the center, the margin ecru drab (R) to pale vinaceous drab (R); context thick at the center, firm, white, unchanging; odor spermatic, strong. LAMELLAE adnexed, often slightly uncinate, rounded at the stipe and the cap margin, ventricose, fairly broad, about 5 × 15 mm., close to crowded; color white or pale gray, becoming wood brown (R). STIPE 3–6 cm. long, 4–7 mm. thick, cylindric or flattened, equal above the large, abruptly emarginate bulb; firm, rigid, solid, the context pallid, unchanging; surface everywhere densely white-pruinose, satiny under this covering; color pallid below, vinaceous-buff (R) or distinctly tinged fawn color (R) upward. SPORES 4–6 × 6–7.5 μ, angular-nodulose, with a few (6 to 8) low, rounded nodules at the angles. PLEUROCYSTIDIA 14–19.5(22) × 56–70 μ, numerous, fusiform-ventricose, very thick-walled apically, the pedicel short and thick or almost lacking; CHEILOCYSTIDIA numerous, more or less evenly distributed along the edge, same size and shape as the pleurocystidia. STERILE CELLS not very numerous, small, clavate, mingled with basidia. TRAMA OF LAMELLAE quite compact, homogeneous, the cells mostly cylindric or somewhat inflated-cylindric, with many slender hyphae present.

In sandy soil along a road through a stand of hemlock, Point Wells, Snohomish County, October 18, 1935 (*379*).

My specimens check exactly with those of many collections of *Inocybe albodisca* Pk. in the herbarium of the University of Michigan. This very distinctive species seems to occur rather commonly in open places in coniferous woods in Washington. It is easily identified by its lubricous pileus with cream colored center and brownish vinaceous or incarnate-vinaceous margin, and its long, rigid, incarnate, densely pruinose stipe, furnished with an abruptly emarginate bulb at the base. It is a typical example of the section Marginatae as defined by Boursier and Kühner (2).



FIGS. 1–9. Species of *Inocybe*.

Kühner (9, p. 101) cites *Inocybe albodisca* Peck and *I. hiulca* Fr. sensu Bresadola as synonyms of *I. grammata* Quél., which he interprets in the same manner as does Lange. On the other hand, Heim (5, pp. 314, 315) gives the name *I. grammata* Quél. to a quite different species, which he says is the same as *I. Bresadolae* Massee sensu Konrad & Maublanc (8, pl. 107). Heim also states that his *I. grammata* Quél. is the same as *I. grammata* Quél. sensu Lange and *I. hiulca* Fr. sensu Bresadola. Such differences in opinion make it difficult to decide what name to use. Although the specimens of my collection No. 379 agree very well with the illustration and description of *I. grammata* Quél. given by Lange (10, p. 86, Tab. 116, fig. D) and by Kühner (9, pp. 101–104), and those of *I. hiulca* Fr. given by Bresadola (3, Tab. 762), I prefer for the present to apply the name *I. albodisca* Pk. to them.

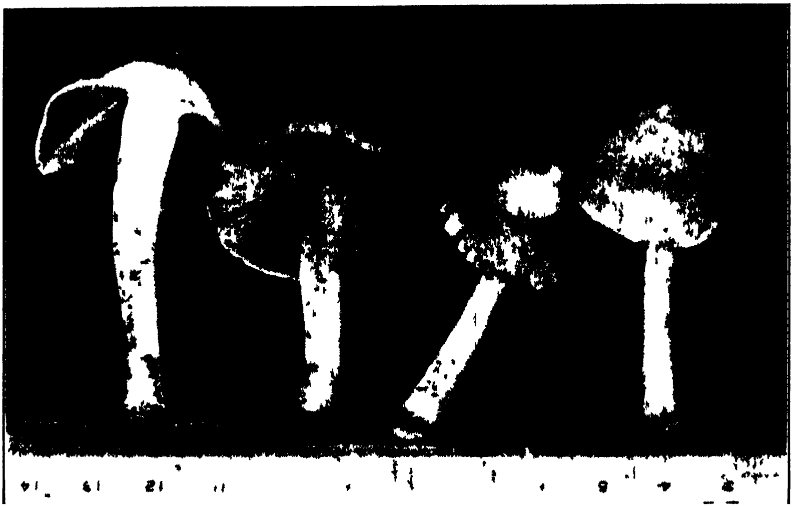


Fig 45. *Inocybe albodisca* Pk, × 1. The numbered divisions on the scale are centimeters

2. INOCYBE CASTANEA Pk. (figs. 3, 4)

PILEUS 2.5–3 cm. broad, obtusely campanulate, becoming expanded, plane, always with a small rounded umbo, margin rounded; surface somewhat lubricous when moist, drying readily, smooth and unbroken at the center, rather coarsely rimose at the margin, sometimes slightly to plainly diffracted-scaly in between: color chestnut (R), bay (R), maroon(341)t.–1, or mineral brown (339)t.–1, 2, sometimes snuff brown (R) toward the margin; context 3 mm. at the center, hygrophanous, gray when moist, drying buff or brown, odor none or resinous, rather aromatic. LAMELLAE adnate, sinuate to abruptly rounded at the stipe, ventricose, the edges convex, notably white-fimbriate and finely eroded; broad, about 4 × 12 mm., close, thin, of several lengths; color Dresden brown (R) to Prout's brown (R) or snuff brown (303) t.–1, 2. STIPE 2.5–3 cm. long, 4–5 mm. thick, cylindrical or flattened, equal or tapering slightly downward, not bulbous; solid, quite firm, the context brown; surface glabrous, satiny, the apex white-pruinose, the pruinosity sometimes extending to the base of the stipe; color snuff brown (303) t.–2 or tawny olive (R) to wood brown (R). SPORES 4.5–6.5 × 7.5–9 μ, merely angular to coarsely nodulose, the number of nodules 10 or less. PLEUROCYSTIDIA 10.5–21 × 55–85(97) μ, numerous, projecting prominently, slender, fusiform or lanceolate, usually absolutely sessile, with the base broadly rounded; thick-walled, especially apically. CHEILOCYSTIDIA numerous, projecting prominently, shaped like the pleurocystidia. STERILE CELLS abundant, in dense clusters, rather small, clavate. TRAMA OF LAMELLAE loosely arranged, the cells large, cylindric-inflated to ventricose or fusiform-clavate, varying in some lamellae, not in others.

On needle litter under Douglas fir and hemlock, Wells Point, Snohomish County, November 15, 1936 (*550, 556*).

The cystidia of *Inocybe castanea* Pk. are striking, with their lanceolate, thick-walled apex and broad, apedicellate, rounded base. Together with the small, obscurely angular spores and chestnut brown pileus, they serve to distinguish this species from the other brown nodulose-spored Inocybes.

The portion of the type collection of *Inocybe castanea* at the herbarium of the University of Michigan consists of three specimens, all of which are smaller and more slender than my plants, but which compare well with mine as to color, spores, and cystidia. A collection of *I. castanea* by Kauffman from Montana shows the same striking microscopic characters, and contains one specimen which is as large as mine. I feel free, therefore, to disregard the size limits of Kauffman's description (7, p. 238), and refer my specimens to Peck's species. This is the first report of *Inocybe castanea* Pk. from Washington.

3. **Inocybe chelanensis**, sp. nov. (FIG. 5–7)

Pileus 2–4 cm. latus, e campanulato convexo-expansus, siccus, centro sericeo-fibrillosus, pallide luteus vel cremeus vel fere albidus, margine fibrilloso-subrimosus, brunneo-vinaceus; caro alba, immutabilis; odor nullus vel vix raphaneus; lamellae rotundato-adnexae, subconfertae, latae, ex albis brunneo-olivaceae; stipes 1.5–4 cm. longus, 4–12 mm. crassus, equalis vel deorsum subattenuatus, solidus, glaber, longitudinaliter striatus, salmoneus vel brunneo-vinaceus; sporae 5.5–8 × 13–19 μ, crasse 4–5-tuberculatae, apice praelongus; pleurocystidia et cheilocystidia fusoidea vel subclavata, 13–20 × 50–90 μ. Specimen typicum legit prope Chesapeake Saddle, Chelan County, Wash., July 8, 1938, D. E. Stuntz n. 659, pars in Herb. Univ. Wash., pars in Herb. Univ. Mich., conservatum.

PILEUS 2–4 cm. broad, convex to campanulate, becoming shallowly convex, finally almost plane; surface of young pileus completely covered with an appressed, pallid, silky coat which as the pileus expands remains at the center but disappears outward, revealing the lacerate-fibrillose, subrimose cuticle; color of center cinnamon buff (R) to pinkish buff (R), nearly white or pale cremeous in some, margin various shades of vinaceous brown, such as Rood's brown (R) or Mikado brown (R); in age the pileus tends to become discolored to shades of tawny olive (R); context thick (4 mm.) clear to the margin, there abruptly thin, firm,.brown under the cuticle, elsewhere white, unchanging; odor almost none, very faintly raphanoid, taste mild. LAMELLAE adnexed to narrowly adnate, sinuate to deeply emarginate, rounded at both ends, ventricose, broad, 5 × 12 mm., edges convex, scarcely or not at all white-fimbriate; somewhat distant, rather thick, rigid; color at first white, becoming Dresden brown (R). STIPE 1.5–4 cm. long, 4–12 mm. thick, usually flattened, rarely cylindrical, equal or tapering downward a little, the apex dilated; solid, rigid, firm, the context white or with an incarnate tinge from the very first, slowly turning a little reddish where bruised; surface satiny, rather markedly longitudinally grammate, with superficial white silky fibrils below, the apex sparingly white-pruinose; color at first buff pink (R) to light vinaceous cinnamon (R), becoming vinaceous cinnamon (R) to orange cinnamon (R), tinged cacao brown (R) in age. CORTINA white, silky, very sparse and evanescent. SPORES 5.5–8 × 13–19 μ, most frequently 6.5 × 16 μ, distally prolonged into a smooth, bullet-shaped apex, bearing one to five large rounded nodules at the basal end, rarely with the entire outline angular or nodulose. PLEUROCYSTIDIA 12.5–19.5 × 50–90 μ, fusiform to clavate, thin-walled, not abundant, deeply embedded in the hymenium, from which they project only 20–25 μ. CHEILOCYSTIDIA same size and shape as the pleurocystidia, not abundant, deeply embedded in the edge of the lamella. STERILE CELLS lacking, the edge of the lamellae fertile, composed of normal hymenial elements. TRAMA OF LAMELLAE very compact, homogeneous, of long, narrow cells which are cylindrical to narrowly fusiform, predominantly the latter. No lactifers seen. Subhymenium deep, cellular.

Gregarious on needles and mineral soil under *Abies* spp. and *Pinus contorta* Loud., Chesapeake Saddle, Chelan County, elevation 6000 ft., July 8, 1938 (*659*, type).

Unique spores distinguish this species from other Inocybes. In the course of their development, the distal half becomes greatly prolonged, remaining smooth, while a few large, round, low nodules develop subsequently at the basal end only. Occasionally the spore develops no nodules, but acquires a sinuous or angular outline, and rarely nodules are developed over the whole surface. Other than its spores, the distinguishing characteristics of *Inocybe chelanensis* are the vinaceous-brown pileus with buff or cream colored center, and the stout, salmon colored to brownish vinaceous stipe. As far as I am able to determine, there are no other species of *Inocybe* to which *I. chelanensis* is closely related. Certain of the specimens of *I. brunnea* Quél. figured by Heim (**5**, pl. XV, fig. 1) look not unlike my plant, but the resemblance is purely superficial. The spores of *Inocybe Rennyi* Berk. & Br. resemble those of *I. chelanensis* in fundamental nature and course of development, but in other respects the two species are quite dissimilar.

4. INOCYBE CICATRICATA Ellis & Ev. (FIGS. 8, 9)

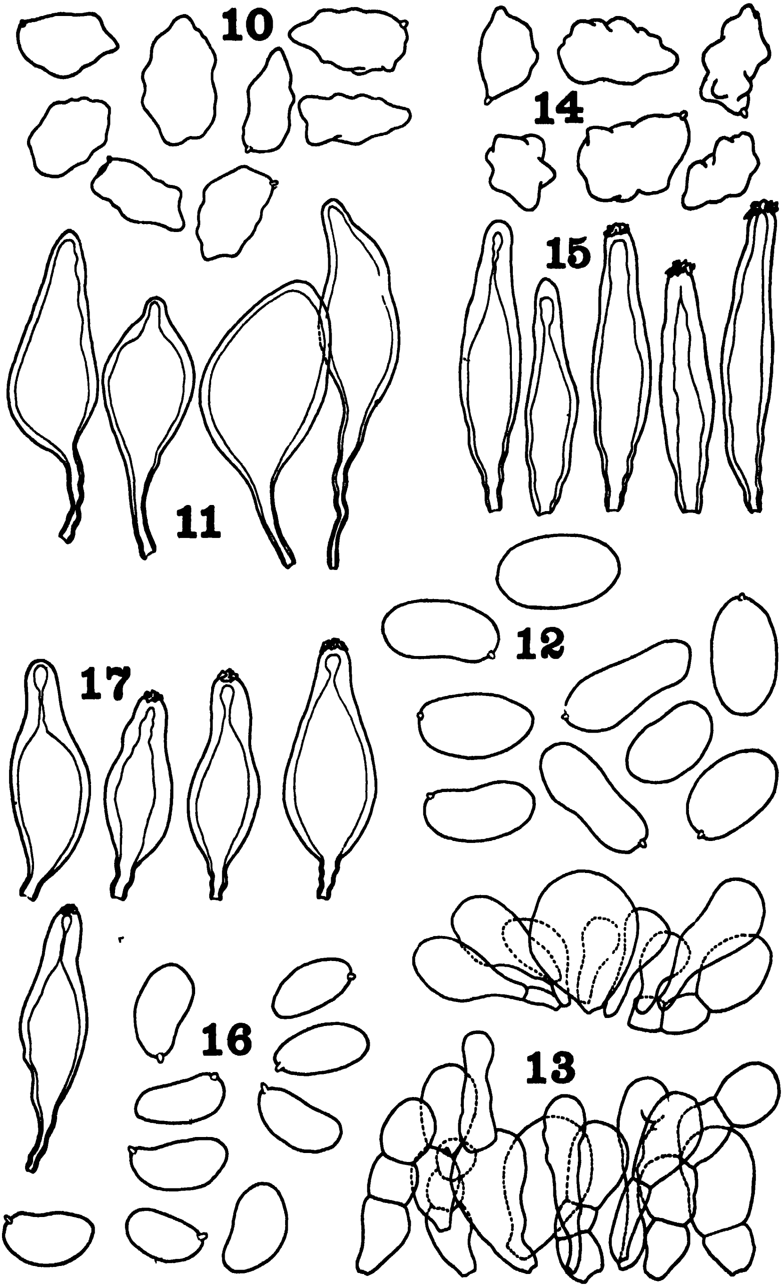
PILEUS up to 2.5 cm. broad, campanulate, becoming obtusely campanulate, umbonate, margin rounded, surface innately radially silky, with a rather thick cuticle, remaining smooth; color when young otter brown (354) t.–4, becoming raw umber (301) t.–1 in age; context 3 mm. at the center, hygrophanous, brown under the cuticle, elsewhere yellowish, odor faintly spermatic. LAMELLAE broadly adnate, decurrent by a short tooth, shallowly sinuate, rounded at the margin, convex, broad, about 5 × 11 mm., subdistant, of two lengths; color smoke grey (363) t.–1, becoming snuff brown (303) t.–1. STIPE 4 cm. long, 5 mm. thick, cylindrical, equal, the base not bulbous, solid; surface satiny, with a few superficial fibrils at the apex (which is not pruinose) and base, color brownish terra cotta (322) t.–1 above, shading into raw umber at the base. SPORES 5.5–6.5(8) × 9.5–12 μ, angular-nodulose, very polymorphic, trapezoidal, oblong, or triangular in outline, usually with the apex prolonged into a long tapering nodule, elsewhere with 5 to 8 coarse, irregular nodules which often distort the outline of the spore into very irregular shapes. PLEUROCYSTIDIA 14.5–19.5 × 53–65–75 μ, not very numerous, fusiform-ventricose to fusiform-clavate above a long slender pedicel, neck lacking or only very slightly differentiated, thin-walled, the wall sometimes slightly thickened apically, hyaline. CHEILOCYSTIDIA numerous, scattered along the edge, a few projecting prominently, resembling the pleurocystidia in size and shape, except that most of them have yellow contents. STERILE CELLS numerous, clustered along the edge, with basidia sometimes intermingled, narrow, clavate. TRAMA OF LAMELLAE compact, homogeneous, the cells of medium size, inflated-cylindrical, sometimes with a median constriction, sometimes somewhat fusiform. Lactifers infrequent, branched.

On needle litter under Douglas-fir, Fort Lewis, June 25, 1937 (*591*).

This collection agrees quite well with Heim's description of *Inocybe cicatricata* Ellis & Ev. (**5**, p. 351). The distinguishing characteristics are the small size, grey-brown pileus, solid dark brown stipe, and coarsely angular-nodulose, polymorphic spores, with a prominent distal elongation. This species has not been reported previously from west of the Rocky Mountains.

5. INOCYBE DECIPIENTOIDES Pk. (FIGS. 10, 11, 46)

PILEUS 1–3.5 cm. broad, campanulate, becoming expanded, convex, finally centrally depressed, always with a very prominent mammiform umbo; surface innately radially silky, satiny-shining, the umbo remaining glabrous, becoming rimulose to rimose toward the margin, or remaining silky-smooth, occasionally with a few appressed silky squamules between center and margin; color of the umbo persistently dark brown, umber, elsewhere buff or brownish ocher or fawn color, wood brown (R), the margin sometimes rather light, almost cream color; context thick at the center, elsewhere thin, firm, white, unchanging, odor spermatic, strong. LAMELLAE adnexed to squarely adnate, often uncinate, subdistant, sinuate, narrowing toward the margin, rather broad, 3–4 mm., edges convex, white-fimbriate; color at first white, long remaining so, becoming gradually pale grayish brown, finally brownish ochraceous. STIPE 4–5 cm. long, 5–7 mm. thick, cylin-



FIGS. 10–17. Species of *Inocybe*.

drical, usually tapering downward, the base never bulbous; solid or stuffed below, often spirally twisted, context fragile, white above, soon becoming brown below; surface satiny-shining, bearing the persistent remains of the copious white cortina above, apex white-pruinose; color pallid to cream color above, buff below at first, soon becoming dark brown at the base, sometimes with an obscure vinaceous tinge. SPORES (4.5)5–7(8) × 8–11(13) μ, varying from merely slightly angular to having 6 to 10 round, low, inconspicuous nodules. PLEUROCYSTIDIA 16–30(36) × 43–72(78) μ, mostly 20 × 55 μ, abundant, mostly inflated-fusiform-clavate above a long slender pedicel; varying considerably in shape and size, sometimes almost mucronate, varying from rather thin-walled to thick-walled laterally or apically. CHEILOCYSTIDIA very abundant, densely crowded along the completely sterile edge, polymorphic like the pleurocystidia but of the same general type. STERILE CELLS few, large and clavate, closely resembling the immature cheilocystidia except for their thin wall. TRAMA OF LAMELLAE loosely woven, extremely heterogeneous, with all sizes and shapes of cells, from enormous inflated-fusiform ones to small, slender connective tissue; lactifers occurring frequently, especially in the subhymenium.

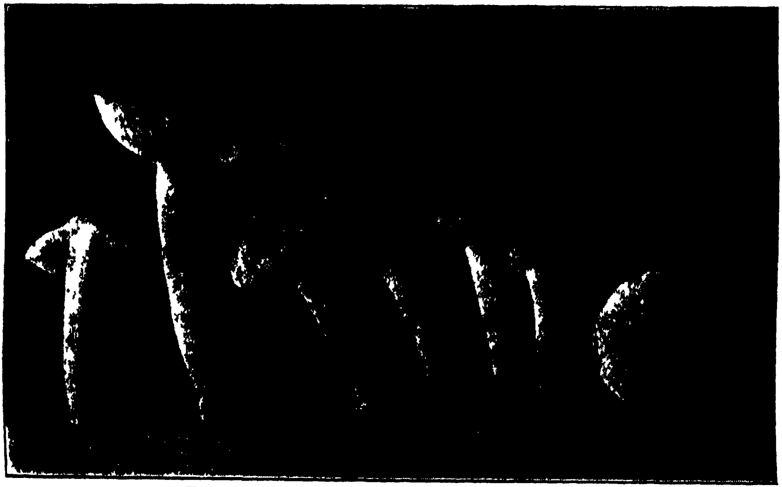


FIG. 46. *Inocybe decipientoides* Pk., × 1.

Gregarious in grass on a lawn, near a single tree of *Abies grandis* Lind., Seattle, April 21, 1934, and several years subsequently (*2*).

The silky-shining pileus with its dark brown prominent umbo and paler margin, the persistently white lamellae, the slender, satiny stipe which turns brown at the base, are all macroscopic characters which distinguish *Inocybe decipientoides* Pk. Microscopically it is readily recognized by its angular, scarcely nodulose spores and broad, fusiform-clavate cystidia. Boursier and Kühner (2, p. 141) make *Inocybe globocystis* Vel. a synonym of this species, a procedure which seems to be justified if one may judge from the description and illustrations of *I. globocystis* given by Heim in his monograph.

6. INOCYBE DULCAMARA (Fr.) Quél. (FIGS. 12, 13)

PILEUS 6.5 cm. broad, shallowly convex, not at all umbonate, margin slightly revolute, wavy, entire; surface dry, entirely covered with tiny recurved hairy squamules from center to margin; color brownish terra cotta (332) t.–3 to Mars yellow (310) t.–4, toward the margin tinged with snuff brown (303) t.–2; context 8 mm. at the center, compact, pale ochraceous, odor faint, a little raphanoid, taste slightly bitter. LAMELLAE adnexed, some narrowly adnate, rather deeply rounded at the stipe, bluntly so at the margin, ventricose, broad, 11 × 25 mm., edges convex, not white-fimbriate, concolorous or discoloring dark brown; subdistant, transversely ridged at the base, sometimes a little intervenose; color a little paler than golden bronze green (298) t.–1. STIPE 3 cm. long, 8 mm. thick, cylindrical, equal, flaring a little at the apex, hollow, the context fibrous, tough, ochraceous, unchanging; surface longitudinally fibrillose, a little strigose below, the apex not pruinose but finely flocculose; color snuff brown (303) t.–2, 3. SPORES 5–7 × 9–13.5 (14.5, 17.5) μ, mostly oval or subreniform, but rather variable in shape, some long and narrow. PLEUROCYSTIDIA and CHEILOCYSTIDIA lacking. STERILE CELLS fairly numerous, clustered along the edge of the lamella, large, clavate or saccate, frequently septate. TRAMA OF LAMELLAE fairly compact but very scissile, heterogeneous, the cells mostly long and slender, inflated-cylindrical usually with a median constriction; many slender hyphae present. Lactifers occasional, long, slender, unbranched.

On moss, along a stream in woods of *Abies* spp. and *Pinus contorta* Loud., Chesapeake Saddle, Chelan County, elevation 6000 ft., August 28, 1939 (*805*).

This *Inocybe* is easily recognized by its pileus which is entirely covered with small, tawny, pilose squarrulae, by its brownish-ocher hollow stipe, broad olivaceous brown lamellae, and by its microscopic characters. I feel some hesitancy in referring it to *Inocybe dulcamara* (Fr.) Quél., a species about which European mycologists are not in agreement. The spores of my plant are a little longer and more variable than described for *I. dulcamara* by either Heim or Lange, but in other respects my specimen agrees quite well with the descriptions and illustrations (5, pl. V, fig. 4, and 10, tab. 114, fig. C) given by these authors.

To judge from the infrequency with which *I. dulcamara* is mentioned by American mycologists, it is a very rare species in the United States. Kauffman does not report it in North American Flora, and I did not find any collections of it in the herbarium at the University of Michigan. This is the first report of it from west of the Rocky Mountains.

7. INOCYBE FULVELLA Bres., sensu A. H. Smith, Heim. (FIGS. 14, 15)

PILEUS 5–13 mm. broad, campanulate, remaining so or expanding somewhat, always umbonate, margin rounded, rarely plane or slightly recurved; surface glabrous at the center, elsewhere with numerous small, diffracted, fibrillose squamules, less often lanuginose or rimose; color tawny (R), ochraceous tawny (R), or russet (R) at the center, buckthorn brown (R) or ochraceous buff (R) toward the margin; context 2–3 mm. at the center, very thin at the margin, pallid brown, hyprophanous, odor spermatic. LAMELLAE adnexed to narrowly adnate, broadly rounded at the margin, narrowed toward the stipe, deeply ventricose, very broad, about 3 × 5 mm., edges convex, minutely pallid-fimbriate; subdistant, moderately thick, of several lengths; color tawny olive (R) or snuff brown (303) t.–1. STIPE 12–25 mm. long, 1–2.5 mm. thick, cylindrical, equal, base not bulbous; solid or stuffed or narrowly fistulose, the context reddish, fragile; surface at first entirely densely white-pruinose, glabrescent and satiny except at the apex; color light pinkish cinnamon (R) to pinkish cinnamon (R) or pinkish buff (R) to cinnamon buff (R), or a pale shade of tawny olive (R), paler at the apex, which may be either white or somewhat incarnate. SPORES 5–7(8.5) × 8–11.5(12) μ, elliptic-angular, with 8 to 12 or 14 more or less prominent rounded nodules. PLEUROCYSTIDIA 11–23 × 40–65(70) μ, abundant, narrowly fusiform, with no neck, sessile or with a very broad, short pedicel; very thick-walled laterally and apically. CHEILO-

CYSTIDIA abundant, occurring singly or in clusters, same shape and size as the pleurocystidia. STERILE CELLS numerous, densely clustered with the cheilocystidia, large and clavate, altogether lacking along some edges, which in consequence are fertile. TRAMA OF LAMELLAE not very compact, rather heterogeneous, the cells mostly large, fusiform-ventricose, varying considerably in size, with many slender hyphae present. Lactifers few and inconspicuous, small, threadlike, in the subhymenium.

In moss on the ground under Douglas fir, Fort Lewis, May 16, 1936 (*442*); in *Polytrichum* sp. and on bare earth, along a road through dense second growth conifers, near Chase Lake, Snohomish County, May 20, 1937 (*585*).

My collections were compared with some referred by A. H. Smith to *Inocybe fulvella* Bres., and were found to match them in every detail except one. Smith describes his specimens as having the lamellae at first "near avellaneous (R)," and the apex of the stipe army brown (R), whereas my plants lack any such brownish vinaceous colors. In this respect they are closer to *I. fulvella* as interpreted by Heim (**5**, p. 322). It seems to me that the limits of Bresadola's species are being made rather vague by the inclusion of forms (my own collections not excepted) which are rather divergent in the matter of color and spore size, and that it might be better to segregate these forms into another species. Such a procedure, however, is not advisable until further data on the variability of these plants can be obtained. The distinguishing characteristics of *Inocybe fulvella* as here understood are its very small size, tawny fibrillose pileus, very broad lamellae, pruinose pinkish buff stipe, large nodulose spores, and thick-walled, slender, fusiform cystidia. The large spores separate it from *Inocybe petiginosa,* (Fr.) Gill. to which it is closely related.

8. INOCYBE GEOPHYLLA Fr. (Quél.) var. LATERITIA Weinm. (FIGS. 16, 17, 47)

Syn.: *Inocybe geophylla* Fr. forma *perplexa* Kauff., Papers of the Mich. Acad. of Sci., Arts, and Letters **5**: 134. 1925.

PILEUS 1–6 cm. broad, usually 3–4 cm., campanulate, becoming expanded and obtusely umbonate, surface lubricous when moist, soon dry, silky-smooth, shining; color at first pure white, in age slightly ochraceous to nearly tawny olive (R) at the center, the whole pileus or parts of it slowly becoming flushed with salmon orange (R), bittersweet pink (R), apricot orange (R) or flesh ocher (R), sometimes at length entirely rufous (R), bittersweet orange (R) or flame scarlet (R); context 4–6 mm. at the center, white, usually slowly becoming reddish where exposed, odor strong, spermatic. LAMELLAE adnexed to adnate, more or less broadly rounded at both ends, ventricose, broad, the edges convex and white-fimbriate, color at first white, becoming cinnamon brown (R) to snuff brown (303) t.–1. STIPE 5–10 cm. long, 4–10 mm. thick, cylindrical, equal, the base not or only slightly rounded-bulbous; solid or sometimes hollow at the apex, context white; surface glabrous, satiny, lubricous below when moist, apex densely white-pruinose; color white, becoming flushed like the pileus with salmon orange (R) or darker, often intensely so. SPORES 4.5–5 × 7–10.5 μ, entire, apex obtusely rounded. PLEUROCYSTIDIA 12–22(26) × 45–65(75) μ, very abundant, fusiform-ventricose with well developed pedicel and neck, thick-walled apically. CHEILOCYSTIDIA numerous, shaped like the pleurocystidia or more globular. STERILE CELLS abundant, clavate to globular, crowded along the sterile edge of the lamella. TRAMA OF LAMELLAE compact, homogeneous, the cells inflated-cylindric to fusiform. Lactifers very few.

FIG 47 *Inocybe geophylla* (Fr) Quél. var *lateritia* Weinm, × 1. Numbered divisions on the scale are centimeters.

In open grassy places under conifers, or on needle litter in conifer woods. Nisqually, October 30, 1934 (*217*); Seward Park, Seattle, November 20, 1934 (*268*), December 20, 1936 (*570, 571, 572*); along the White River, October 17, 1935 (*397*); Wells Point, Snohomish County, October 14, 1936 (*507*), October 31, 1936 (*534*), November 15, 1936 (*542a*); Tenino Junction, Pierce County, October 25, 1936 (*528*); Clay Creek, White River road, November 8, 1936 (*542*).

The intensity and time of appearance of the red stains of pileus and stipe vary greatly; they may be already well developed by the time the sporocarp is mature, or they may not be evident until after the plants have been collected, or even until they are dried. From the above statement, it is evident that the form described by Kauffman as forma *perplexa* cannot be separated from the variety *lateritia* Weinm. In Washington this rubescent variety is very common; in fact, it is sometimes more abundant than the white form of *I. geophylla.*

The perplexing question of the relation of *Inocybe geophylla* var. *lateritia* to *I. Godeyi* Gill. still awaits a solution. According to Lange and Kauffman, the difference between them is chiefly one of size and stoutness of the sporocarp, which in *I. geophylla* var. *lateritia* is small and slender, with an acuminate pileus. If this distinction were applied, many of the Washington collections would be referred to *I. Godeyi,* as many of them are robust plants, with an obtusely umbonate pileus. However, in Washington the white form of *I. geophylla* varies in size and shape from small and slender to large and robust, and a similar variation occurs in the rubescent variety. Therefore it would be very hard to draw a line that would separate *I. geophylla* var. *lateritia* from *I. Godeyi* sensu Lange and Kauffman. I have examined a collection from Michigan which was identified by Kauffman as *I. Godeyi,* and found it to have spores that are broader and more gibbous dorsally than those of my plants. Also, Dr A. H. Smith, who made the Michigan collection, said the sporocarps were more rapidly and intensely rubescent than any he had seen of *Inocybe geophylla* var. *lateritia.* I therefore prefer to use the latter name for the common rubescent *Inocybe* of Washington. It may be that the collection from Michigan represents *I. Godeyi* sensu Heim, which certainly differs in several respects from the descriptions of *I. Godeyi* given by Lange and Kauffman.

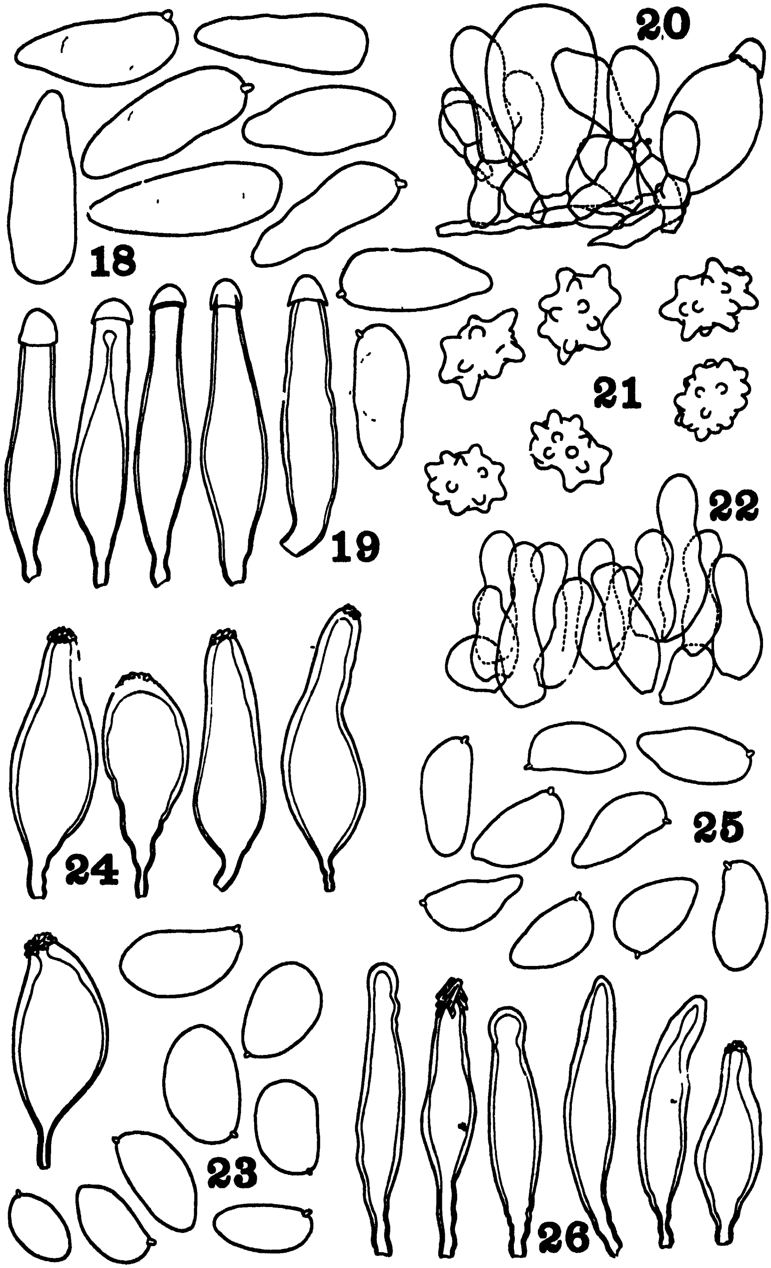
9. **Inocybe Hotsoniana**, sp. nov. (FIGS. 18–20)

Pileus 3.5 cm. latus, plano-expansus, late umbonatus, siccus, sericeo-fibrillosus, semper eodem modo fulvo-olivaceus; caro pallida, immutabilis; odor tenuiter raphaninus; lamellae late adnatae, subdistantes, 3–4 mm. latae, laete olivaceo-brunneae; stipes 6 cm. longus, 7 mm. crassus, aequalis, basis non bulbosus, solidus, appresso-fibrillosus, pileo concolor; sporae 5–7 × 12–20 µ, elongato-amygdaliformes vel cylindraceae; pleurocystidia et cheilocystidia abundantia, 12–17 × 60–82 µ, cylindraceo-subventricosa; apex crassitudine pileo simili praeditus. Specimen typicum legit prope Tenino Junction, Pierce County, Wash., October 25, 1936, D. E. Stuntz n. *525*, in Herb. Univ. Wash. conservatum.

PILEUS 3.5 cm. broad, becoming expanded, nearly plane, broadly umbonate, the margin even, entire, plane, surface dry, rather densely silky-fibrillose becoming a little rimulose toward the margin, color uniformly tawny olive (R); context 6 mm. at center, elsewhere 3 mm., firm, pallid, odor faint, subraphanoid, not spermatic. LAMELLAE broadly and squarely adnate, very shallowly rounded at the stipe, bluntly rounded at the margin, asymmetric-ventricose, widest outward, not broad, about 3–4 × 13 mm.; edges eroded, white-fimbriate; of several lengths, subdistant; color Dresden brown (R). STIPE 6 cm. long, 7 mm. thick, equal, tapering slightly downward, the base not at all bulbous, solid, fibrous, surface satiny beneath a covering of more or less abundant superficial fibrils, color same as that of the pileus, but a little paler, and with a silvery sheen. SPORES 5–7 × 12–17–20.4 µ, elongate-amygdaliform to cylindric, usualy bluntly pointed or subconic apically; wall thick, tawny. PLEUROCYSTIDIA 12–17 × 60–73–82 µ, abundant, quite constant in size and shape, subcylindric, a little ventricose near the base, pedicel broad, poorly developed, apex obtuse, with a distinct cap-like thickening of the wall, very seldom muriculate; wall rather thin, yellow. CHEILOCYSTIDIA abundant, in clusters, projecting prominently, same general shape as the pleurocystidia, but more polymorphic, often broadly ventricose or saccate. STERILE CELLS abundant, clustered with the cystidia, large, clavate to capitate, basidia sometimes also intermingled. TRAMA OF LAMELLAE fairly compact, very heterogeneous, the cells varying greatly in shape from oval or vesiculose to narrowly cylindric; fusiform-ventricose, cylindric-inflated, sinuous, etc., also varying greatly in size, but predominantly large. Lactifers not seen.

Solitary on moss and conifer-needles under Douglas fir, near Tenino Junction, Pierce County, October 25, 1936 (*525*, type).

This species is well characterized by the uniform brownish ochra-



FIGS. 18–26. Species of *Inocybe*.

ceous color of pileus and stipe, the broadly adnate, dark olivaceous brown lamellae, the long cylindrical spores with a subconic apex, and the cystidia with their peculiar cap-like thickening at the apex. The only really closely related species seem to be *Inocybe Poujoli* Heim and *I. fulvida* Bres. The former differs in its much smaller size, paler and more ochraceous color, spermatic odor, differently attached lamellae, and absence of pleurocystidia. The latter differs in its more fulvous pileus, sinuate-free lamellae which do not become olivaceous, marginate-bulbed stipe, somewhat shorter spores, and much broader pleurocystidia.

I take pleasure in dedicating this species to Dr. J. W. Hotson, whose active interest in the Agaricaceae of the West Coast has been a source of inspiration for many years.

10. INOCYBE LEPTOPHYLLA Atk. (FIGS. 21, 22)

PILEUS 3 cm. broad, obtusely campanulate, margin rounded, even, surface densely squarrose with small, hispid, erect, pointed, tuft-like scales, very crowded at the center, more appressed toward the margin, which is roughly lacerate-tomentose; color very dark brown, almost black at the center, auburn (R) at the margin; context thick at the center, firm, hygrophanous, pale smoke grey (R) when moist, odor faint, fungoid. LAMELLAE adnate, rounded at the stipe, tapering toward the margin, ventricose, edges convex, finely pallid-fimbriate, broad, about 5 × 13 mm., thin, close, color between snuff brown (R) and Verona brown (R). STIPE 4 cm. long, 5 mm. thick, cylindrical, equal, base not bulbous, solid, fibrous; surface tomentose-hairy below, apex scurfy, color Mikado brown (R) at the apex, shading into Argus brown (R) at the base. SPORES 7–8.5 × 9–11 μ, elliptical, covered with fifteen to twenty small round nodules, preserving the elliptical outline perfectly. PLEUROCYSTIDIA and CHEILOCYSTIDIA lacking. STERILE CELLS abundant, densely clustered along the edge, clavate or saccate, with a median or apical constriction (capitate), thin-walled, large, 11–13.5 × 35–45 μ. TRAMA OF LAMELLAE very compact, homogeneous, the cells practically all fusiform-ventricose, varying somewhat in size.

On rotten wood in dense coniferous forest, Cataract Creek, Carbon Glacier, Mt. Rainier, September 4, 1936 (*475*); same locality, on the ground along a path, August 12, 1937 (*611a*).

There is no difference in outward appearance between this species and *Inocybe lanuginosa* (Fr.) Quél., but the complete lack of pleurocystidia and the ellipsoid spores with 15–20 small regular nodules serve to distinguish *I. leptophylla.* Heim (5, p. 365) and Boursier and Kuhner (1, p. 177) describe and illustrate as *I. Casimiri* Vel. a species to which my collections of *I. leptophylla* might very well be referred. They stress the importance of the ellipsoid spores with many small nodules as a distinguishing character of *I. Casimiri.* Evidently a study of the type of *I. leptophylla* is needed to determine whether or not it has the same type of spore. If the two species prove to be synonymous, *I. leptophylla* Atk. is the older name.

This is the first report of *I. leptophylla* from Washington.

FIG. 48 *Inocybe lucifuga* (Fr.) Quél., × 1.

11. INOCYBE LUCIFUGA (Fr.) Quél. (FIGS. 23, 24, 48)

PILEUS 3–4.5 cm. broad, campanulate, becoming expanded and shallowly campanulate, with a small mammiform umbo, margin lacerate, split, very irregular, surface appressed-fibrillose, remaining smooth at the center, becoming deeply rimose toward the margin, finally lacerate, excoriate, but never squamulose; color buff (309) t.–1 to bistre (328) t.–2 at the center, shading into chamois (325) t.–3, 4 at the margin; context 3–5 mm. at the center, hygrophanous, ocher below the cuticle, elsewhere white or pallid, odor faintly raphanoid, lacking in some specimens. LAMELLAE narrowly to broadly adnate, sometimes uncinate with a tooth, shallowly rounded at the stipe, bluntly so at the margin, ventricose, rather broad, 6–8 × 16–17 mm., edges convex, white-fimbriate or not, turning brown in age; subdistant, regularly alternating in various lengths; color at first clear pale olivaceous, becoming near Isabella color (R), finally golden bronze green (298) t.–1. STIPE 2–5 cm. long, 4–6 mm. thick, cylindrical, equal or slightly incrassated downward, base not bulbous; solid, the context soft along the axis, compact but very fragile at the periphery, white or yellow-tinged, unchanging; surface glabrous, satiny, or with a few white fibrils below, apex white-pruinose; color white, flushed with Naples yellow (29) t.–1, especially toward the apex. SPORES 5–8 × 8–12.5(13) μ, mostly 7 × 10.5 μ, ovate-amygdaliform, the apex usually obtuse. PLEUROCYSTIDIA 14.5–25.5 × 50–70 μ, rather few, scattered over the surface of the lamellae, ventricose, with a slender pedicel and short neck, sometimes clavate, only slightly thick-walled apically. CHEILOCYSTIDIA abundant, scattered along the edge, usually wider than the pleurocystidia, sometimes surmounted by an amorphous globule. STERILE CELLS abundant, large, clavate, loosely clustered along the edge. TRAMA OF LAMELLAE rather loosely arranged, heterogeneous, the cells inflated-ventricose to fusiform-clavate or globular, most of them large.

Gregarious to subcespitose on needles and moss under *Abies* spp. and *Pinus contorta* Loud., along a stream, Chesapeake Saddle (elevation 6000 ft.), Chelan County, August 28, 1939 (*802*).

The uniformly ochraceous pileus, yellowish-olivaceous lamellae, white satiny stipe, and faint raphanoid odor are the distinguishing characteristics of this species. The flesh of both pileus and stipe is notably fragile, almost watery. My specimens are in excellent agreement with the description given by Heim (5, p. 201), and they also compare very well with a collection in the herbarium of the University of Michigan referred to *Inocybe lucifuga* by Kauffman. *I. lucifuga* seems to be a rare plant in North America; Kauffman did not include it in his monograph, and I can find no reference to it in any of the other American publications I have consulted.

12. INOCYBE OBSCURA (Fr.) Gill. (FIGS. 25, 26)

PILEUS 2–3 cm. broad, obtusely campanulate, becoming expanded and umbonate, surface at first silky-fibrillose, becoming slightly diffracted-squamulose at the center, rimulose toward the margin which is finally lacerate; color Sayal brown (R) at first, becoming ochraceous tawny (R), sometimes darker, Vandyke brown (R) to sorghum brown (R); context 2 mm. at the center, odor spermatic. LAMELLAE adnate, sinuate, uncinate, obtusely rounded at the margin, rather broad, about 4 × 12 mm., very ventricose, edges convex, finely white- or brown-fimbriate, subdistant; color at first vinaceous buff (R) to light greyish vinaceous (R) or light vinaceous fawn (R), soon becoming Sayal brown (R) to snuff brown (R). STIPE 3.5–5.5 cm. long, 3.5–5 mm. thick, cylindrical, equal, the base slightly incrassated; surface satiny, with some superficial fibrils, the apex pruinose; color wood brown (R) below, becoming pallid, apex light russet-vinaceous (R) to russet-vinaceous (R), becoming in old specimens vinaceous-brown (R) or sorghum brown (R). SPORES 5–6 × 10.5–12 μ, amygdaliform, often pointed apically, and with a dorsal apicular depression. PLEUROCYSTIDIA 12–19 × 60–80 μ, abundant, ventricose-fusiform, usually slender, with more or less well defined pedicel, thick-walled apically. CHEILOCYSTIDIA numerous, not projecting prominently, in sparse clusters along the edge. STERILE CELLS abundant, clavate, large and conspicuous, often septate. TRAMA OF LAMELLAE loosely arranged, heterogeneous, the cells fusiform-inflated, variable in shape and size, with many slender hyphae present. Lactifers numerous in the subhymenium, forming an anastomosing network.

In conifer woods, Duval, July 2, 1935 (*330*); in grass under *Corylus californica,* (A. DC.) Rose, Seward Park, Seattle, May 6, 1936 (*428*); in grass under *Corylus californica,* (A. DC.) Rose, University of Washington campus, Seattle, May 7, 1937 (*428a, 429*).

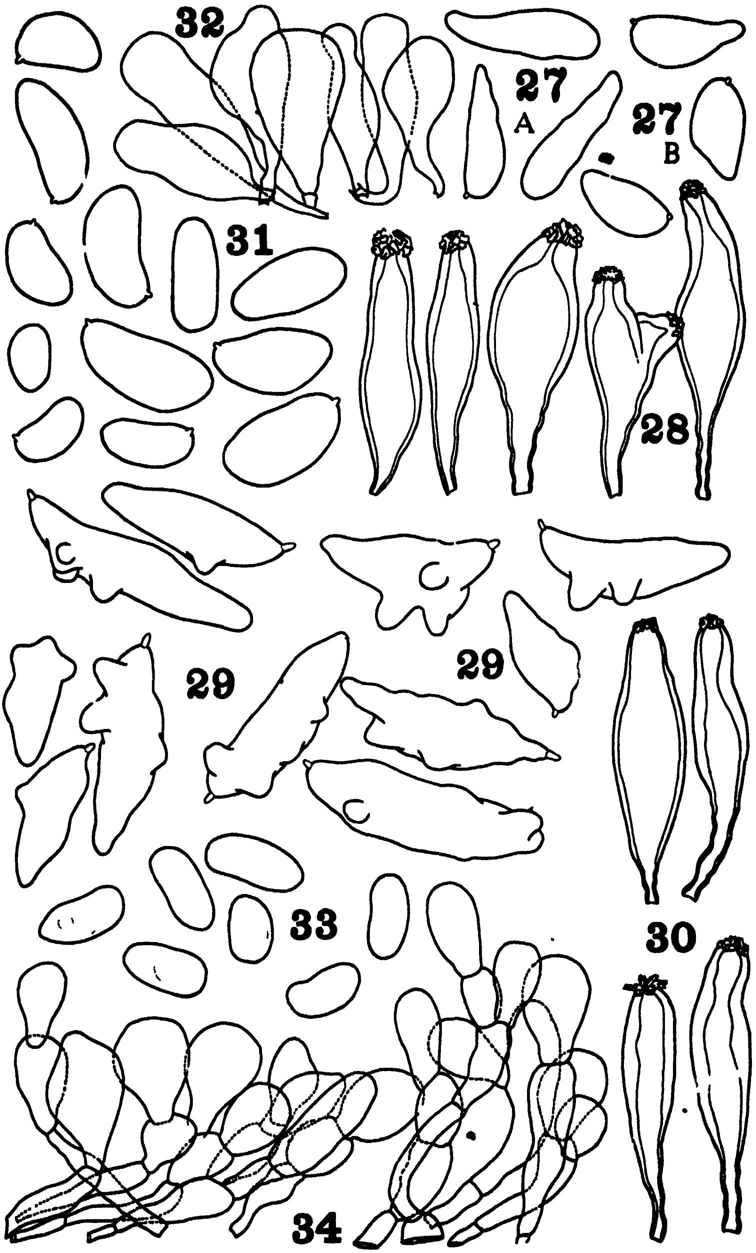
The plant described above answers best to the generalized description given by Heim (5, p. 253) of *Inocybe obscura,* (Fr.) Gill. except that the lamellae and apex of the stipe are vinaceous instead of some shade of violaceous. *I. obscura* var. *purpurea* Heim is very similar, but it is said to have the lamellae chamois at first. The question of what constitutes typical *Inocybe obscura* can hardly be said to have been settled by European mycologists, as anyone can see by consulting the publications of Lange, Heim, and others. I should like to make it clear that I do not consider my plant to be "typical" *I. obscura,* but merely a form whose color and other characters ally it more closely to this than to any other species.

13. INOCYBE OBSCURA (Fr.) Gill., Var. RUBENS Heim (FIGS. 27, 28)

PILEUS 1–4 cm. broad, usually 2–2.5 cm., campanulate, becoming expanded and finally plane, always umbonate, surface innately radially fibrillose, the umbo remaining glabrous, elsewhere silky-smooth or becoming very slightly rimulose, the margin becoming decorated with one or two ranks of tiny triangular fibrillose squamules, each tipped with white silky fibrils; color at first uniformly maroon (341) t.–2, 3, the umbo remaining so, elsewhere becoming burnt umber (304) t.–3, 4, paler when dry; context thin (3 mm. at the center), firm, hygrophanous, red-brown under the cuticle, elsewhere greyish, drying pallid, a little rose-tinged, unchanging; odor rather faint, but clearly spermatic. LAMELLAE narrowly adnate, shallowly rounded at the stipe, bluntly rounded at the margin, ventricose, moderately broad, 3 × 9 mm. to 5 × 12 mm., edges convex, even, not notably white-fimbriate; only moderately close, rather thick, sometimes intervenose; color smoke gray (363) t.–1, becoming more or less snuff brown (303) t.–1, 2. STIPE 2–5.5 cm. long, 2–6 mm. thick, cylindrical, equal, the base usually not bulbous but occasionally with a small rounded bulb; solid, the context fibrous, softer along the axis, yellowish or brownish below, rose colored or rosy vinaceous above, unchanging, surface glabrous, satiny, the apex white-pruinose; color pale pink (135) t.–4 or yellowish salmon (65) t.–1–4 or salmon flesh (138) t.–4, becoming tinged brown below. SPORES 4–6.5 × 9–16 μ, most commonly 5.5–6.5 × 9.8–11.5 μ, quite variable in size and shape, sometimes markedly apically constricted and prolonged. PLEUROCYSTIDIA (11)12–26.5(39) × 53–85(92) μ, abundant, fusiform-ventricose above a pedicel of variable length and thickness, usually lacking a well-defined neck, thick-walled. CHEILOCYSTIDIA numerous, projecting prominently, same size and shape as the pleurocystidia. STERILE CELLS abundant, long and conspicuous, clavate, densely crowded in a broad zone along the edge, with basidia sometimes intermingled. TRAMA OF LAMELLAE compact, the cells rather variable in size, fairly uniform in shape, fusiform, with many narrow cylindrical ones present.

Subcespitose to gregarious in moss on rotten wood or on the ground, beside a stream in woods of *Abies* spp. and *Pinus contorta* Loud., Chesapeake Saddle (elevation 6000 ft.), Chelan County, August 28, 1939 (*801*).

Apparently this variety of *I. obscura* (Fr.) Gill. had not been collected since Heim described it in 1931. My specimens conform



FIGS. 27–34. Species of *Inocybe*.

best to "forme b" of the two forms included in the variety (5, pp. 260–263). Their distinguishing macroscopic characters are the maroon pileus with tiny but conspicuous and persistent white marginal squamules, the incarnate stipe, and gray lamellae. Heim describes the pileus color as "brun-noir" or "brun purpurin" rather than maroon, and the lamellae as pallid ("blanchâtre") rather than gray at first, but because color is such a variable character in Inocybes, these discrepancies seem to me to be of minor importance. In one specimen of my collection the spores are predominantly of the long, narrow, distally tapered type illustrated in fig. 27a; in the remaining specimens they are shorter and more normal in shape (fig. 27b), with only an occasional elongated one among them. Heim mentions the same variation in spore size and shape (5, p. 263, fig. 169).

There is a certain amount of confusion and lack of agreement among mycologists concerning the several species and forms closely related to *I. obscura* (Fr.) Gill. It does not seem to me that this confusion is any the less for the inclusion of forms like var. ***rubens*** Heim which entirely lack the chief distinguishing character of the *obscura* group; namely, a violet or lilac color of the stipe or lamellae or both. Whether or not to exclude such forms, however, is a matter best left until the *I.. obscura* complex in North American has been investigated more thoroughly.

14. INOCYBE RENNYI Berk. & Br. (FIGS. 29, 30)

PILEUS 1.5–4 cm. broad, hemispherical or campanulate, becoming obtuse or broadly campanulate, umbonate or not, surface dry, densely strigose-fibrillose to merely silky, becoming diffracted-scaly with numerous erect, pointed squarrae, the margin rimose and lacerate; color dark brown, the center raw umber (R) or mummy brown (R) or bistre (R), elsewhere Brussels brown (R) to Prout's brown (R); context 2–3 mm. at the center, firm, white or pallid, odor faint, mildly fungoid. LAMELLAE adnexed and deeply sinuate, or adnate, abruptly rounded at the stipe, bluntly pointed at the margin, ventricose, rather broad, 4 × 10 mm., edges very convex, finely white-fimbriate; close, of several lengths; color at first white, becoming cream buff (R), finally snuff brown (303) t.–2. STIPE 2–4 cm. long, 4–7 mm. thick, equal, cylindrical, base not bulbous, solid, the context white, unchanging; surface lanuginose like that of the pileus but less densely so, and not scaly, apex densely white-pruinose; color avellaneous (R) to wood brown (R) above, Verona brown (R) to warm sepia (R) below. SPORES 6–10 (11.5) × 11.5–22 μ, very polymorphic, greatly prolonged apically, elsewhere bearing a few very large, coarse nodules, with the apiculus mounted on a mammiform projection. PLEUROCYSTIDIA 10.5-19.5 × 60–80(95) μ, not very abundant, clavate, with a long, slender pedicel and little or no neck, wall laterally thickened. CHEILOCYSTIDIA numerous, not projecting prominently, smaller than the pleurocystidia. STERILE CELLS numerous, clavate, almost as large as the cheilocystidia, intermingled with basidia along the partially fertile edge. TRAMA OF LAMELLAE not very compact, the cells mostly large, inflated-cylindric or ventricose-inflated; lactifers fairly abundant, large, sinuous, unbranched.

Under Douglas fir, Fort Lewis, May 16, 1936 (*438*); in woods of *Abies* and *Pinus contorta* Loud., Mt. Constitution (elevation 2400 ft.), Orcas Island, August 13, 1937 (*610*).

No other species of *Inocybe* has the greatly elongated, coarsely and often grotesquely nodulose spores that characterize *I. Rennyi* Berk. & Br. They are formed from the smooth, amygdaliform immature spores by the extreme elongation of the apex, followed by the formation of a few large, coarse nodules on the main body of the spore. Some of the macroscopic characters of this species seem to be rather variable. Thus, the specimens of No. *438* had umbonate, silky pilei, adnate lamellae, and a strong odor, whereas those of No. *610* had obtuse pilei with the surface like that of *Inocybe lanuginosa* (Fr.) Quél., adnexed lamellae, and the odor none or very faint. The presence of scales on the pileus is not mentioned by Heim, Rea, or Massee, nor shown in Cooke's illustration (4, pl. 520).

So far as I am aware, this is the second report of *Inocybe Rennyi* from North America. A. H. Smith has illustrated the spores and cystidia of specimens collected in Massachusetts (13, p. 100).

15. INOCYBE SORORIA Kauff. (FIGS. 31, 32)

PILEUS 2.5–7 cm. broad, narrowly conic-campanulate, or mitrate, long remaining so, finally shallowly campanulate or plane, with a prominent mammiform umbo, margin persistently appendiculate with conspicuous patches of white silky veil, finally glabrescent, rimose or deeply excoriated; surface at first smooth, silky-shining, soon deeply and conspicuously rimose everywhere except the umbo; color Naples yellow (29) t.–1, 2 or creamy white (10) t.–2, 3, 4 or ivory yellow (R), tinged Colonial buff (R) in some, and with the umbo darker, Naples yellow (29) t.–3, 4 to almost fulvous; context thin, firm, white, unchanging, odor very strong, of "green corn," not at all spermatic, very persistent. LAMELLAE adnexed to narrowly adnate, rounded at both ends, shallowly ventricose, rather narrow, 3 × 20 mm., thin, crowded, color Isabella color (R) to buffy citrine (R) or bistre green (296) t.–3, becoming golden bronze green (298) t.–1, finally Dresden brown (R). STIPE 5–13 cm. long, 4–10 mm. thick, equal or tapering slightly upward, cylindrical, base incrassated, rather abrupt, or rounded-bulbous in some; solid or stuffed, becoming hollow in some, context fragile, white, usually spirally twisted, surface rather densely white silky-floccose, the fibrils aggregated in small irregular flocci; color white, becoming tinged with dingy yellow or straw color below. SPORES 5.8–8(8.8) × 11–15.5(17) μ, ovoid to subreniform, very variable in size and somewhat so in shape. PLEUROCYSTIDIA and CHEILOCYSTIDIA lacking. STERILE CELLS abundant and conspicuous, crowded in a broad band along the edge of the lamella, one-celled, saccate, or clavate to subcapitate, very variable in shape and size, 13–28(35) × 45.5–73.5(81.5) μ.

Under Douglas fir and *Larix* spp., Thunder Bridge Forest Camp, October 20, 1940 (*929*).

This species is closely related to *Inocybe fastigiata* (Fr.) Quél., from which it differs in its ivory or pale cream colored pileus and its strong, persistent, very characteristic odor of green corn. In the original description (7, p. 259), Kauffman describes the odor rather vaguely as "somewhat pungent or lacking," which may account for the reluctance of some European mycologists to accept *I. sororia* as a valid species. Heim considers it to be synonymous with *I. fastigiata* (5, p. 184, footnote), but I cannot agree with him. Both species occur rather frequently in the conifer forests of Washington, and the differences between them are constant. The strong green corn odor of *I. sororia* is especially characteristic, and easily distinguished from the typically spermatic odor of *I. fastigiata*.

16. INOCYBE SUBDECURRENS Ellis & Ev. (FIGS. 33, 34, 49)

PILEUS 2–3.5 cm. broad, campanulate, becoming expanded, obtuse, finally plane, with a rather prominent umbo, the margin persistently incurved, lobed and wavy, surface densely appressed-lanuginose, becoming irregularly lacerate but not rimose, persistently covered with white superficial fibrils which are irregularly aggregated, forming squamules toward the margin, color cinnamon buff (R), quite uniform except where the white fibrils make it somewhat paler; context thin, firm, pale ocher, unchanging, without odor. LAMELLAE squarely and broadly adnate, uncinate, moderately broad, about 3.5 × 10 mm., hardly ventricose, close, many times inserted; edges plane, conspicuously white-fimbriate, color at first Isabella color (R), becoming Dresden brown (R) to Prout's brown (R). STIPE 3–4 cm. long, 4–5 mm. thick, equal cylindrical, base not at all bulbous; hollow, context ochraceous; surface fibrillose, the fibrils forming tiny aggregates, with remains of the ample white cortina persisting for a time at the apex; color pinkish buff (R) to cartridge buff (R). SPORES 4.5–5.5(6) × 8–10(11) μ, predominantly reniform or subreniform, some ovate-subcylindrical; apiculus lacking. PLEUROCYSTIDIA and CHEILOCYSTIDIA lacking. STERILE CELLS closely crowded in a broad band along the edge of the lamella, al-

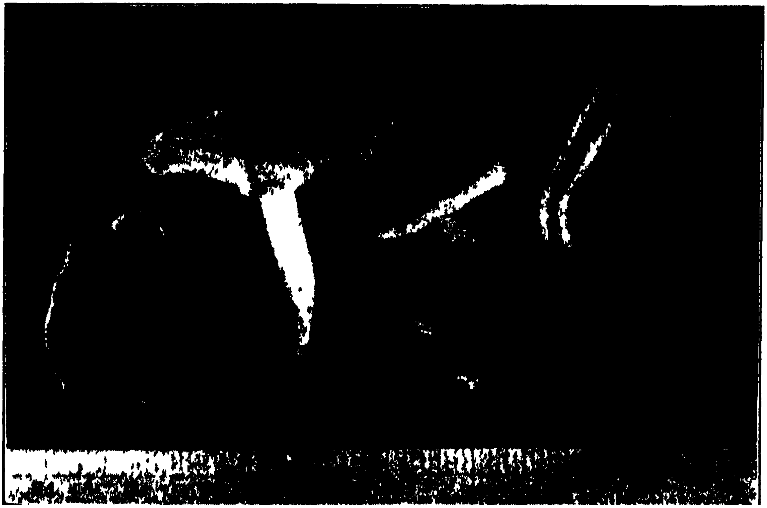


FIG. 49. *Inocybe subdecurrens* Ellis & Ev., × 1.

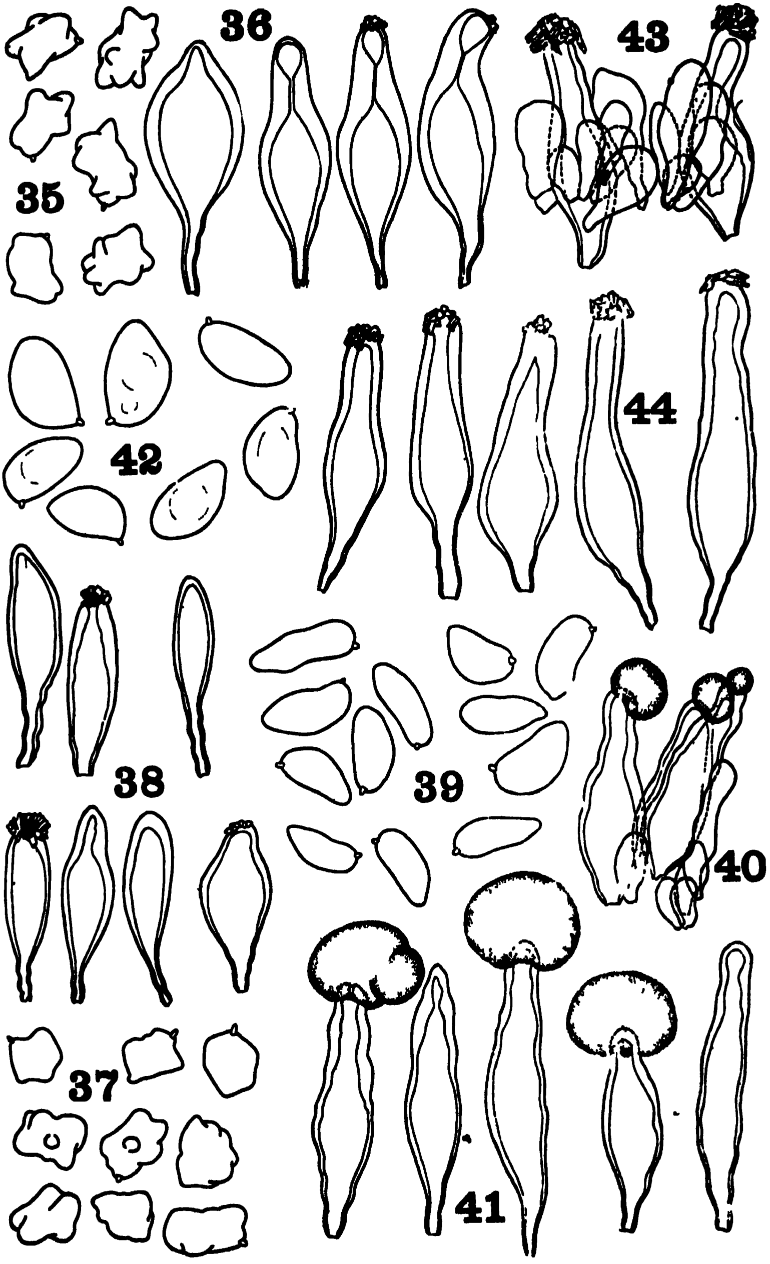
most always composed of 3 or 4 swollen cells, the terminal one of which is inflated-clavate or saccate, single-celled ones also present. TRAMA OF LAMELLAE very compact, homogeneous, the cells practically all inflated-cylindrical with a broad median constriction, varying somewhat in length but hardly at all in shape.

Gregarious on humus under *Alnus rubra* Bong. and *Acer macrophyllum* Pursh., Agate Pass, Bainbridge Island, July 18, 1937 (*604*).

Portions of the types of *Inocybe subdecurrens* E. & E. and *I. tomentosa* E. & E. (which are synonymous) deposited in the herbarium of the University of Michigan were examined, and my specimens were found to compare very well with them. Also, they fit the description given by Kauffman of *I. subdecurrens* (7, p. 257), except in having definitely olivaceous lamellae. In Heim's monograph they can be identified as *I. perbrevis* (Weinm.) Gill., but I hesitate to refer them to this species, which is figured and described by Cooke, Rea and Massee as being fulvous or tawny, and having the stipe very short. Heim's description does not apply too well to his figures (5, pl. V, fig. 2), which (at least the group in the middle, right) look very much like my plants. This is the first report of *I. subdecurrens* from Washington.

17. INOCYBE TRECHISPORA (Berk.) Karst., sensu Kauffman (FIGS. 35, 36)

PILEUS 4–4.5 cm. broad, obtusely campanulate to convex, becoming expanded, plane, with a broad shallow umbo, margin obtuse, surface very viscid when wet, almost slimy, drying satiny-shining, center unbroken, elsewhere more or less rimose; color tawny (R) to cinnamon brown (R) at the center, elsewhere Buckthorn brown (R) to Dresden brown (R); context thin, hygrophanous, firm, pallid or white; odor spermatic. LAMELLAE adnexed to nearly free, obtusely to shallowly rounded at the stipe, shallowly rounded at the margin, ventricose, rather broad, about 4 × 15 mm., edges convex, finely white-fimbriate and eroded; close, thin, of several lengths; color at first pale argillaceous, becoming drab (R), finally dark fawn (307) t.–1, 2 or snuff brown (R). STIPE 4–6 cm. long, 5–9 mm. thick, cylindric or flattened, equal above the small but definitely emarginate bulb, solid, rigid, fibrous; surface everywhere densely white-pruinose, satiny beneath the pruinosity, color ivory yellow (R) to cartridge buff (R), becoming



FIGS. 35–44. Species of *Inocybe*.

pinkish buff (R). SPORES 4.5–6(7) × 7.5–10(10.5) μ, angular-nodulose, the nodules coarse, large, rounded, 5–9 in number, PLEUROCYSTIDIA 13.5–22(25) × 45–65 μ, numerous, obese, inflated-ventricose, rounded apically, with a short neck and well defined pedicel, very thick-walled apically and laterally. CHEILOCYSTIDIA numerous, in dense, well separated clusters, or smaller groups mixed with sterile cells; shorter and broader than the pleurocystidia. STERILE CELLS numerous, small, clavate, clustered with the cheilocystidia. TRAMA OF LAMELLAE compact, homogeneous, the cells inflated-cylindric, varying somewhat in size and slenderness; lactifers few, large, sinuous, not or only seldom branched.

On needle litter under Douglas fir, Wells Point, Snohomish County, October 14, 1936 (*506*), November 15, 1936 (*552*).

This is one of the very few Inocybes with a really viscid pileus. The viscidity and the rigid, pallid, marginate-bulbed stipe distinguish it from other Inocybes with nodulose spores.

There seem to be at present at least two different interpretations of *Inocybe trechispora* (Berk.) Karst. That of Kauffman agrees essentially with Bresadola's concept of the species. On the other hand, Heim, Lange, and Rea describe a slender, pallid plant with white or ivory pileus, and lacking an emarginate bulb at the base of the stipe. Kühner has abandoned the name *I. trechispora* (9, p. 91), and describes as *I. mixtilis* Britz. a species which he says is the same as *I. trechispora* sensu Kauffman. It should be noted, however, that he does not describe the pileus of his species as being viscid.

My specimens check exactly with the description given by Kauffman (7, p. 234), and also with several collections in the herbarium of the University of Michigan referred to *I. trechispora* by both Kauffman and A. H. Smith. This is the first report of *I. trechispora* from Washington.

18. INOCYBE UMBRINA Bres. (FIGS. 37, 38)

PILEUS 2.5–4 cm. broad, campanulate, becoming expanded and furnished with a broad, low umbo, surface lubricous when moist, soon drying silky-smooth, center glabrous, elsewhere conspicuously long-rimose, color raw umber (R) to mummy brown (R) at the center, elsewhere cinnamon brown (R) to Prout's brown (R) or Dresden brown (R); context 5 mm. at the center, elsewhere thin, hygrophanous, pallid or ochraceous, odor none or faintly raphanoid. LAMELLAE adnate, uncinate, emarginate, seceding at length, broad, 5 × 15 mm., ventricose, edges convex, finely pallid-fimbriate; close and thin, color snuff brown (R), Saccardo's umber (R), tawny olive (R), Sudan brown (R) or Brussels brown (R). STIPE 5–6 cm. long, 4–5 mm. thick, cylindrical, equal or tapering slightly upward, the base rounded-bulbous, solid or hollow, the context fragile; surface satiny, with a few superficial fibrils, the base white-myceloid, apex white-pruinose; color at first Mikado brown (R) to onion-skin pink (R), becoming Verona brown (R) to Sayal brown (R), darker at the base. SPORES 4.5–6.5 × 6–8(9) μ, varying from merely angular to coarsely nodulose, with 5 to 8 low, obtuse nodules. PLEUROCYSTIDIA 10–17(21) × 36–50(60, 75) μ, fusiform-clavate to clavate above a slender pedicel, thick-walled apically. CHEILOCYSTIDIA not very numerous, not projecting prominently, grouped in the clusters of sterile cells. STERILE CELLS numerous, cylindric to clavate or saccate, densely clustered, often mingled with basidia. TRAMA OF LAMELLAE homogeneous, compact, the cells mostly rather short, inflated-cylindric or ventricose; lactifers few, thread-like, small.

Along paths under conifers, Wells Point, Snohomish County, January 25, 1936 (*414*), November 15, 1936 (*518*); Carbon River road, near Fairfax, August 30, 1936 (*466*).

The umber brown, distinctly rimose pileus, brown stipe, and small angular to obscurely nodulose spores distinguish this species from the other members of the *umbrina* group. My specimens agree very well with the descriptions of *Inocybe umbrina* by Heim, Lange, Bresadola and Kauffman; they constitute the first record of this species from Washington.

19. INOCYBE VISCIDULA Heim (FIGS. 39–41)

PILEUS up to 3 cm. broad, convex-campanulate, becoming expanded, finally shallowly convex, not umbonate, surface viscid when wet, composed of agglutinated fibrils which are aggregated at the center, rimose toward the margin, which is decorated with white patches of cortina; color raw Sienna (R) at the center, elsewhere near Isabella color (R) but paler; context 3 mm. at the center, hygrophanous, translucent, gray, firm, odor faint, subraphanoid. LAMELLAE adnexed to narrowly adnate, somewhat sinuate, shallowly rounded at the stipe, bluntly rounded at the margin, broad, about 4 × 11 mm., ventricose, edges shallowly convex, finely eroded; color near Saccardo's umber (R) but paler. STIPE up to 4.5 cm. long, 7 mm. thick, cylindrical, equal, the base with a very slight subemarginate bulb, solid, firm, the context white, unchanging, surface satiny, shining, longitudinally grammate, with superficial white fibrils, more abundant at the base where they form conspicuous white scales; apex white-pruinose; color pure white. SPORES 4–5 × 8–11 μ, smooth, often with a median or basal dorsal depression, sometimes rather pointed apically. PLEUROCYSTIDIA 10–17(19.5) × 55–80 μ, ventricose or fusiform or almost cylindrical, thick-walled apically, almost always surmounted by a large round globule of amorphous substance. CHEILOCYSTIDIA identical with the pleurocystidia, abundant, in dense clusters along the edge. STERILE CELLS lacking, edge of lamella fertile, made up of normal hymenial elements and cystidia. TRAMA OF LAMELLAE very compact, homogeneous, of small cylindrical or slightly cylindric-inflated cells. No lactifers seen.

In needle duff under Douglas fir, near Chase Lake, Snohomish County, October 3, 1936 (*502*).

The globular or reniform amorphous masses that surmount each cystidium are very distinctive. As illustrated in this paper they may appear somewhat larger than normal, due to the material having been revived by dilute potassium hydroxide. My plants differ from the description of *Inocybe viscidula* given by Heim (5, p. 132) in being somewhat larger, in having the stipe pure white, the pileus not acutely umbonate, and the spores narrower. The very striking cystidia make me inclined to overlook these discrepancies in referring my collection to Heim's species. The macroscopic characters of *I. viscidula* may be more variable than the original description indicates, and in any event, no other species of *Inocybe* has been described with the same kind of cystidia.

The present collection is the first record of *Inocybe viscidula* from North America, or from any other locality, as far as I can determine, since it was first found by Heim in 1927.

20. **Inocybe volvata**, sp. nov. (FIGS. 42–44, 50)

Pileus 2–2.5 cm. latus, campanulatus demum plano-expansus, umbonatus, siccus, glaber, sericeus, castaneus vel badius; caro tenuis, pallide grisea, immutabilis; odor fortis, spermaticus; lamellae adnexae, ventricosae, 3 mm. latae, subdistantes, ex albis sordide brunneae; stipes 2.5–4 cm. longus, 2–5 mm. crassus, aequalis, basis leviter bulbosus vel non, membrana alba volvae

valde simili praeditus, mox cavus, glaber, incarnatus, apice albo-pruinatus; sporae 5–7 × 7–10.5 μ, leves, amygdaliformes; pleurocystidia et cheilocystidia 12–18 × 62–90 μ, ventricosa, pedicellata. Specimen typicum legit prope Chase Lake, Snohomish County, Wash., D. E. Stuntz n. *400*, pars in Herb. Univ. Wash., pars in Herb. Univ. Mich., conservatum.

PILEUS 2–2.5 cm. broad, campanulate, becoming expanded and finally plane, but remaining always umbonate; surface even, smooth, innately radially silky, at most only slightly rimulose at the margin, which becomes split, and is persistently decked with white submembranous patches; color auburn (R) to Vandyke brown (R) or warm sepia (R), context thin, hygrophanous, pale grayish honey color, odor strong, spermatic. LAMELLAE adnexed, sometimes almost free, subdistant; ventricose, moderately broad, about 3 × 10 mm, edges convex, finely white-fimbriate, color at first white or pallid, becoming tawny olive (R) to snuff brown (R). STIPE 2.5–4 cm. long, 2–5 mm. thick, equal, cylindrical or slightly flattened in some, base slightly rounded-bulbous or not, furnished with a short, peronate, white membranous sheath, forming a volva-like structure, the upper margin of which may roll back, or be appressed to the stipe; solid, becoming hollow in age, the context incarnate, unchanging, surface satiny, glabrous, the apex white-pruinose; color pinkish buff (R) to light pinkish cinnamon (R). SPORES 5–7 × 7–10.5(11.5) μ, amygdaliform, with ventral or dorsal apical depression or both. PLEUROCYSTIDIA 12.5–18(19.5) × 62–90 μ, numerous, fusiform-ventricose above a slender pedicel, the neck more or less well developed; thin-walled to moderately thick-walled. CHEILOCYSTIDIA numerous, usually shorter and broader than the pleurocystidia. STERILE CELLS abundant, conspicuous, broadly clavate, in dense clusters along the edge. TRAMA OF LAMELLAE rather

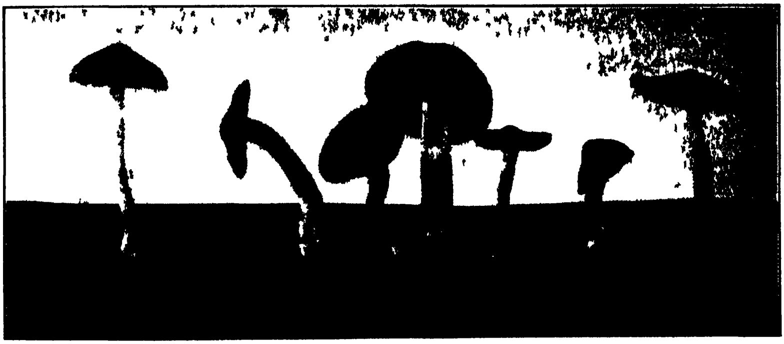


FIG 50 *Inocybe volvata* Stuntz, × 1.

loosely woven, very heterogeneous, predominantly of medium sized fusiform-inflated cells, varying much in shape and size, from vesiculose to cylindrical, with an extraordinary number of slender hyphae present; hyphae intertwining somewhat, flexuous or sinuous. No lactifers seen.

Along a road under Douglas fir and hemlock, near Chase Lake, Snohomish County, November 30, 1935 (*400*-type).

In very young sporocarps there is a white membranous veil which is attached to the pileus margin and sheathes the base of the stipe. When this ruptures, it does so near the pileus margin, on which it leaves remnants in the form of white patches, and forms at the base of the stipe a volva-like sheath. In half the specimens of the type collection the margin of this sheath had rolled back, forming a structure that looked not unlike the volva of *Amanita pantherina* Fr.; in the remainder of the specimens it was evident, but remained appressed to the stipe. Although it is not unusual for the remains of a copious cortina to form a more or less evanescent volva-like prolongation of the edge of a marginate bulb, the presence of a definitely membranous basal sheath is unusual in *Inocybe*.

In addition to the sheath, the distinguishing characters of *Inocybe volvata* are its dark red-brown smooth pileus, incarnate stipe which becomes hollow, and long narrow cystidia. Disregarding the sheath, it bears a superficial resemblance to *Inocybe brunnea* Quél. sensu Heim, which, however, differs in the larger spores and rubescent context. It also reminds one of some of the forms with incarnate stipe included by Heim in his *Stirpe obscura*. None of the species in Kauffman's monograph (7) seems closely related to it.

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UNIVERSITY OF WASHINGTON,
SEATTLE, WASH.

EXPLANATION OF FIGURES

FIGS. 1–9. 1, pleurocystidia of *Inocybe albodisca*. 2, eight spores of *I. albodisca*. 3, pleurocystidia of *I. castanea*. 4, five spores of *I. castanea*. 5, portion of a cross section of the edge of a lamella of *I. chelanensis*, showing deeply embedded cheilocystidia, mingled with fertile basidia. 6, pleurocystidia of *I. chelanensis*. 7, nine spores of *I. chelanensis*. 8, pleurocystidia of *I. cicatricata*. 9, ten spores of *I. cicatricata*.

FIGS. 10–17. 10, eight spores of *Inocybe decipientoides*. 11, pleurocystidia of *I. decipientoides*. 12, spores of *I. dulcamara*. 13, sterile cells of *I. dulcamara*. 14, six spores of *I. fulvella*. 15, five pleurocystidia of *I. fulvella*. 16, spores of *I. geophylla* var. *lateritia*. 17, five pleurocystidia of *I. geophylla* var. *lateritia*.

FIGS. 18–26. 18, spores of *Inocybe Hotsoniana*. 19, five pleurocystidia of *I. Hotsoniana*. 20, sterile cells and a cheilocystidium of *I. Hotsoniana*. 21, spores of *I. leptophylla*. 22, sterile cells of *I. leptophylla*. 23, spores of *I. lucifuga*. 24, four pleurocystidia of *I. lucifuga*. 25, spores of *I. obscura*. 26, pleurocystidia of *I. obscura*.

FIGS. 27–34. 27a, three long, distally tapered spores of *Inocybe obscura* var. *rubens*. 27b, three of the normal type of spore of *I. obscura* var. *rubens*. 28, five pleurocystidia of *I. obscura* var. *rubens*. 29, eleven spores of *I. Rennyi*. 30, four pleurocystidia of *I. Rennyi*. 31, twelve spores of *I. sororia*. 32, sterile cells of *I. sororia*. 33, seven spores of *I. subdecurrens*. 34, sterile cells of *I. subdecurrens*.

FIGS. 35–44. 35, six spores of *Inocybe trechispora*. 36, four pleurocystidia of *I. trechispora*. 37, spores of *I. umbrina*. 38, seven pleurocystidia of *I. umbrina*. 39, spores of *I. viscidula*. 40, cheilocystidia and sterile cells of *I. viscidula*. 41, five pleurocystidia of *I. viscidula*. 42, seven spores of *I. volvata*. 43, two cheilocystidia and several sterile cells of *I. volvata*. 44, five pleurocystidia of *I. volvata*.

BRAZILIAN CHYTRIDS. X. NEW SPECIES WITH SUNKEN OPERCULA

JOHN S. KARLING[1]

(WITH 56 FIGURES)

In a previous publication concerning a *Diplophlyctis*-like endooperculate chytrid from Amazonas, Brazil, the author (9) reported the isolation and culture of four additional species with sunken opercula. These species are largely extramatrical in relation to their substrata and possess large sporangia with one to several exit papillae or tubes, and coarse richly-branched rhizoids which usually arise from several points on the periphery of the sporangium. In these characteristics they are similar to species of *Rhizophlyctis,* but the presence of operculate sporangia excludes them from this genus as it is now interpreted by most chytridologists. At the time of their discovery no operculate genus of this type was known in which they could be placed, so the author established a new genus for them. However, before the description of this genus and species had gone to press, Miss Johanson (6) published a paper in which she showed that a very similar species, *Rhizophlyctis rosea,* is likewise endoöperculate. Therefore, she created a new genus for chytrids of this type with sunken opercula and named it after the author, which eliminated the necessity of the genus proposed by him. Accordingly, the operculate species from Brazil are here transferred to this genus, but in so doing the author is placed in the embarrassing position of adding new species to a genus which bears his name.

The first of these Brazilian species to be described is characterized by spherical zoöspores which contain from ten to more than forty minute hyaline granules, coarse irregular rhizoids, exo- and endoöperculate sporangia, and brown resting spores. The lack of pigment and the presence of numerous minute hyaline granules in the protoplasm impart to the zoöspores and mature zoösporangia a

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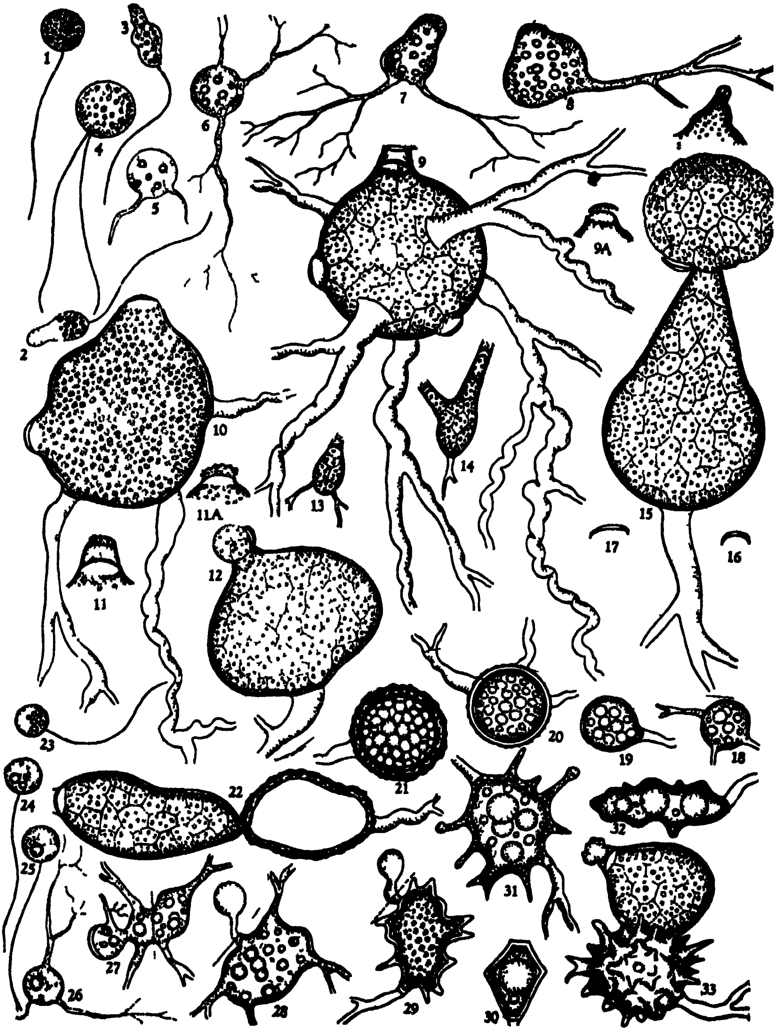
[1] This work has been greatly facilitated by a Grant-in-Aid of Research from the Graduate Faculties of Columbia University.



FIGS 1–22. *Karlingia granulata*
23–33. *K spinosa*

distinctive grayish-granular appearance quite unlike that of *Karlingia rosea.* Because of this characteristic difference it is diagnosed as a new species and named *K. granulata.*

Karlingia granulata sp. nov. (FIGS. 1–22)

Sporangiis hyalinis, laevibus, sphaericis, 8–240 μ, pyriformibus, 6–50 × 10–120 μ, ovalibus, 8–60 × 10–90 μ, elongatis vel irregularibus; 1–5 papillis exeuntibus vel tubulis, 5–8 × 7–110 μ. Rhizoidibus plerumque a pluribus locis in sporangiorum superficie emergentibus, principibus axibus plerumque crassis diametro attingentibus 12 μ, maxime ramosis et extensis. Operculo hyalino, tenui, apiculato vel submerso in papillis exeuntibus vel tubulis, vadosis, figura ad modum patellae vel crateris usque ad 15 μ diametro. Zoosporis hyalinis sphaericis, 5.5–6.5 μ, plurimis granulis minutis praestantibus, flagello 35–40 μ longo. Sporis perdurantibus laevibus vel rugosis, fuscis, pariete crasso praeditis, 2–3.5 μ diam., sphaericis, 6–25 μ, ovalibus, 10–20 × 13–25 μ; germinatione a prosporangio.

Saprophytic in decaying vegetable debris in moist soil samples, San Carlos, Matto Grosso, Brazil.

The developmental cycle of this species is shown in figures 1 to 22. The zoöspores are spherical during the active swimming phase (FIG. 1), but they may come to rest and creep about occasionally as amoebae with their long flagellum trailing behind (FIGS. 2, 3). Quite often unequal or incomplete cleavage occurs in the sporangia with the result that large multiflagellate zoöspores are produced (FIG. 4). In some sporangia zoöspores varying from 10 to 16 μ in diameter with four to eight flagella have been observed. However, the larger ones usually fail to escape with the normal-sized zoöspores and may continue to swarm in the sporangia for more than an hour. After a motile period of twenty to seventy minutes, the zoöspores come to rest and form one to four germ tubes which penetrate the substratum or radiate in several directions (FIGS. 5, 6) and develop into the main axes of the rhizoidal system. In cases in which only one germ tube is formed, the resulting thalli have monoaxial rhizoidal systems as are shown in figs. 8, 12, 14, and 15. The mature rhizoids are usually very coarse with the main axes up to 12 μ in diameter, richly branched, and may extend for almost a millimeter in distance in large thalli. They are characteristically constricted and irregular in outline with conspicuous trabeculae extending into the lumen (FIG. 9). As they increase in age, the walls thicken and become brown in color.

While the germ tubes are branching and developing into rhizoids, the body of the spore enlarges and eventually becomes the sporangium, as in species of *Rhizophlyctis*. Often, one side of the spore becomes thick walled with the result that the sporangium may have a thickened region or cap on one side (FIGS. 7, 8). In rare instances only part of the zoöspore enlarges into a sporangium while the other part remains unchanged as a hemispherical appendage at one side. In such cases it looks as if the sporangium had budded out from the zoöspore body. The mature sporangia of *K. granulata* vary markedly in size and shape, as is shown in figs. 9, 10, 12, 13, 14, and 15. As the substratum or culture medium becomes depleted in available food, the thalli and sporangia become increasingly smaller, so that sporangia with only four (FIG. 13) to sixteen zoöspores may often be found. As was noted before, the protoplasm of mature sporangia and zoöspores includes numerous minute granules which give it a grayish granular appearance quite unlike the rosy pink or light orange to golden color of *K. rosea.*

This species is normally monocentric; but in exceptional and rare cases it may become polycentric. Among the thousands of thalli studied, five were polycentric. Three of these had large primary sporangia and a small secondary one, as in *Phlyctorhiza variabilis* Karling (1946), whereas the other two had secondary and tertiary sporangia.

One of the distinguishing characteristics of *K. granulata* is the occurrence of exo- and endoöpercula. Fig. 9 shows a large spherical sporangium with three exit papillae, two of which are capped by exoöpercula. The third papilla, however, contains a small amount of opaque material, under which lies an endoöperculum. That this figure does not represent a case of sporangial proliferation is evident from the fact that all stages in the formation of such opercula can be readily followed in living material. In other sporangia the tip of the papilla or tube deliquesces (FIGS. 11, 11A) as the protoplasm retracts slightly, and eventually an operculum is formed a short distance down in the tube, as is shown in figs. 13 and 14. The development of the operculum in such cases is very similar to that described for *Nowakowskiella granulata, N. macrospora, Nephrochytrium amazonensis, Karlingia rosea* and *Catenomyces persicinus* by the author (8, 10), Miss Johanson (6) and Miss Hanson (1), respectively, with the exception that no large, sharply-defined plug of hyaline material is formed at the tip. In a few sporangia the exoöperculum had separated from the rest of the papilla along a jagged line and was pushed off by an endooperculum which formed underneath (FIG. 9A). In such cases two opercula were developed in succession by one exit papilla.

The majority of sporangia so far observed were exoöperculate, and as the zoöspores emerged, the opercula were pushed up and folded back (FIGS. 12, 15) or lifted off directly. Nevertheless, *K. granulata* shows a marked variation from exo- to endoöperculate sporangia. The opercula are usually shallow and saucer-shaped as shown in figs. 16 and 17. So far, no retracted opercula within the empty sporangia, like those found by Miss Johanson in *K. rosea,* have been observed in this species.

Another notable difference is the behavior of the emerging zoospores. In *K. rosea* the first zoöspores form a small globular mass at the exit orifice but soon disperse and swim away, while the remaining ones in the sporangia swarm rapidly and eventually emerge. In *K. granulata,* on the other hand, the initial behavior of the zoöspores is like that of *Endochytrium, Septochytrium, Nephrochytrium,* and other similar species. The zoöspores emerge slowly (FIG. 12) and form a large mass at the exit orifice where they remain inactive for longer periods of time. The peripheral spores then gradually become active, disengage themselves and swim away, and within a few minutes the whole mass is dispersed.

Resting spores developed readily in laboratory cultures of this species, and occurred in such profusion that substrata like bits of cellophane, onion skin, and corn leaves became dark brown in color. The young spores soon become distinguishable from incipient sporangia by an accumulation of refractive globules in the cytoplasm (FIG. 18) and a thickening of the wall (FIG. 19). As they mature, the outer layer of the wall turns brown and often becomes slightly rough (FIGS. 20, 21). At the same time, the globules increase in number and become closely packed together, as shown in fig. 21. The spores may remain in this condition for two to three months after which they germinate under normal laboratory conditions. In this process a pore is formed in the wall through which the content grows out and develops into a thin-walled hyaline zoösporangium (FIG. 22). Such sporangia may be exo- or endoöperculate like the primary ones described above.

Karlingia spinosa sp. nov. (FIGS. 23–43)

Sporangiis laevibus, sphaericis, 5–400 μ, pyriformibus, 5–160 × 10–200 μ, ovalibus, 4–70 × 7–100 μ, elongatis, angularibus vel irregularibus; 1–18 papillis exeuntibus vel tubulis, 4–10 μ longitudine × 3–7 μ diametro ab infimo, quarum fines implantae sunt obturamento hyalino glutinoso, quod usque ad 5–12 μ supra verticem terminari potest. Rhizoidibus plerumque a pluribus locis in sporangiorum superficie emergentibus, principibus axibus plerumque crassis, diametrum, attingentibus 10 μ, maxime ramosis et extensis. Operculo hyalino, tenui, submerso in papillis exeuntibus vel tubulis, vadosis figura ad modum patellae vel crateris usque ad 8 μ diam.; expulsis et oblatis, zoosporis emergentibus, aliquibus—operculis accessoriis desorptis in sporangia, zoosporis emergentibus et pressione interna relaxante. Zoosporis sphaericis vel minime ovalibus, 3.3–4.4 μ diam., cum 1–5 granulis minutis praestantibus; maturis initialibus emergentibus saepe globuloso cumulo formato, orifice tubuli exeuntis postea enantibus; flagello 28–32 μ longitudine. Sporis perdurantibus sphaericis, 6–22 μ, ovalibus, 8–12 × 10–15 μ, fusiformibus, elongatis, clavatis, minime rectangularibus 5–8 × 12–17 μ, stellatis vel irregularibus, pariete crasso praeditis, 2–2.5 μ, spinosis vel verrucosis, rebus contents granulosis et globulosis refractivis, colore luteo-fulvosum; germinatione a prosporangio.

Saprophytic in decaying vegetable debris in moist soil samples from San Carlos, Matto Grosso, Brazil.

This species was found in the same culture with *K. granulata* and *K. rosea* and gets its name from the spiny and verrucose character of the resting spore wall. The type of development, growth, structure, and appearance of the thalli as well as the behavior of the zoöspores are so similar to those of *K. rosea* described by Miss Ward (12) and Miss Johanson (6) that it is not necessary to describe them here in detail. However, several differences have been observed, and the present description will be limited to them.

The zoöspores are smaller than those of *K. granulata* but approximately the same size as those of *K. rosea.* However, instead of containing a large number of minute granules, as in these two species, they include from one to six golden brown refringent globules (FIGS. 23–26). The smaller globules often coalesce so that by the time the zoöspores come to rest and germinate, only one globule is present (FIGS. 25, 26). However, this characteristic is not always reliable enough for diagnostic purposes. The number and size of the globules appears to be dependent to some degree on the rapidity with which the sporangia mature and shed their zoöspores. In old sporangia which failed to dehisce, the spore initials contained only one globule. The zoöspores usually germinate extramatrically and develop into thalli in the same manner as described for *K. granulata* and *K. rosea,* but occasionally the branched germ tube swells at the point where it enters the substratum and develops into an irregular incipient sporangium instead of becoming the main rhizoidal axis. In such instances the sporangia become partly intra- and extramatrical with the zoöspore and one or more small rhizoids attached as an appendage (fig. 27). In very rare and exceptional cases the sporangium and rhizoids may be formed entirely within the substratum. In the development of such thalli the incipient sporangium begins as a swelling in the intramatrical portion of the branched germ tube. As it enlarges, the incipient rhizoids are spread apart and become more or less radially arranged on the periphery of the sporangium (fig. 28). The empty zoöspore case and a portion of the penetration tube, in the meantime, remain attached on the outside. Such thalli are rare as far as present observations go but their occurrence shows that the type of development of a species is not absolutely fixed and unvarying. Each species apparently has a normal type of development from which it may vary in different degrees.

Another but less reliable difference between *K. rosea* and *K. spinosa* is the golden red color of the protoplasm of the latter species in contrast to the rosy pink of *K. rosea.* However, as has been noted by most students of the latter species, the color varies from a faintly-perceptible pink in small sporangia to almost red in the larger ones, and similar but not so extensive variations have been found in *K. spinosa.* Therefore, this character cannot always be regarded as distinctive for species which are otherwise very similar. Another variation observed in *K. spinosa* may be noted here. In old cultures several of the exit tubes became thick-walled at the tip instead of deliquescing, and with further elongation they often became curved, so that the mature sporangium bore from three to eight slightly bent, horn-like structures on its surface in addition to the coarse rhizoids. In such thalli the sporangial wall also became unusually thick and brown in color as the sporangia went into a dormant stage. It is not improbable that similar horned sporangia may possibly be found in *K. rosea* also.

In the more normal sporangia the tip of the exit tube deliquesces and forms a plug of hyaline material, while the operculum develops underneath. The subsequent behavior of the operculum and zoospores as they are discharged is so similar to that described by

Miss Johanson for *K. rosea* that it need not be repeated here. It will suffice to note that as the zoöspores are discharged from other exit tubes and the internal pressure is reduced, a few opercula are often sucked down into the sporangium. Furthermore, in old cultures cleavage is sometimes unequal so that large zoöspores are formed. In several sporangia giant multiflagellate zoöspores up to 20 μ in diameter were found which included a golden refractive globule 5 to 12 μ in diameter. Because of their large size, such spores were unable to escape and degenerated within the sporangium after a motile period of one-half to two hours.

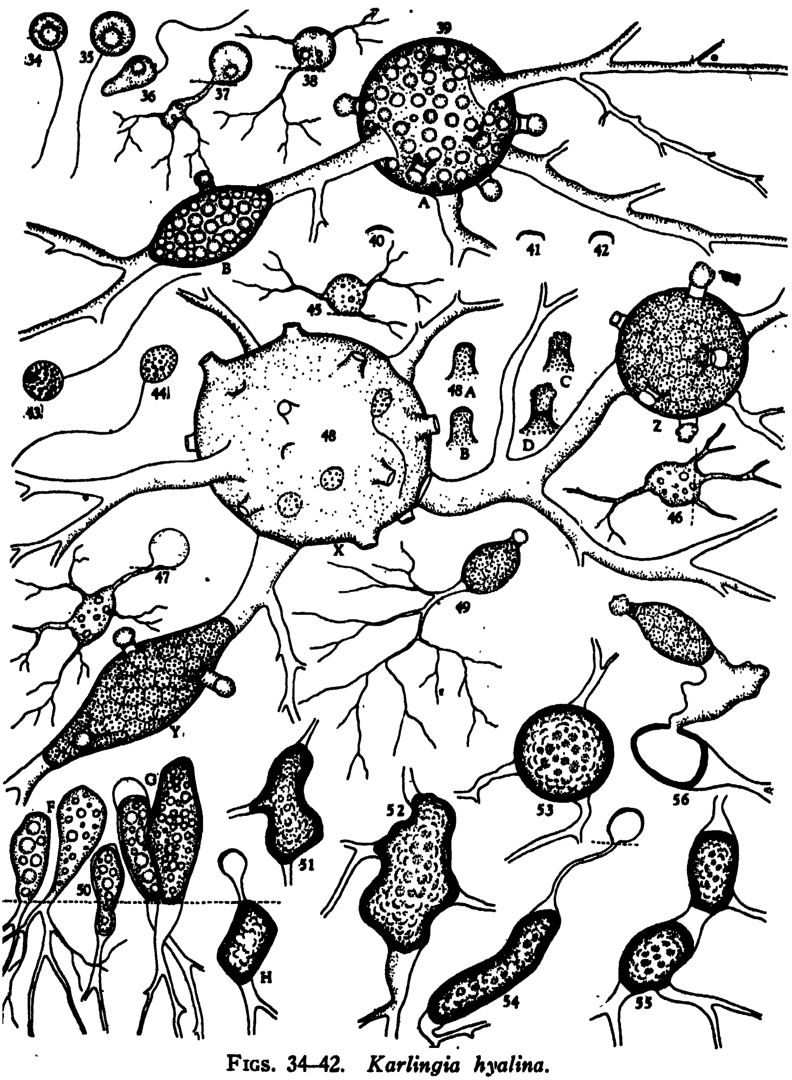
The most distinguishing feature of *K. spinosa* is the spiny and verrucose wall of the resting spores, which occur in abundance as the cultures become old. Like those of *K. granulata,* they develop in the same manner as the sporangia up to a certain stage. Later the wall begins to thicken, becomes warty or spiny and turns golden brown, while the protoplasm becomes coarsely granular and filled with numerous golden globules. The latter gradually coalesce to form several larger globules (FIGS. 30–32). In a few cases completely intramatrical resting spores were found with attached empty zoöspore cases and germ tubes (FIG. 29). These apparently developed in the same manner as the intramatrical sporangia described above. The abruptly tapering spines or pegs are usually solid and may sometimes be tipped by a definite knob (FIG. 31). They may also become slightly curved and bifurcate. Quite often they may be reduced to blunt pegs or warts (FIG. 32). After a rest period of from two to four months under laboratory conditions, the resting spores germinate in the same fashion described above for *K. granulata.* Fig. 33 shows a germinated spore in surface view with the attached zoösporangium.

In this connection it may be noted that *K. spinosa* has recently been isolated from soil collected near Sharon, Conn., U. S. A. The American specimens are similar in structure and development to those from Brazil. However, some of the spines on the resting spores were up to 12 μ in length.

Karlingia hyalina sp. nov. (FIGS. 34–42)

Sporangiis hyalinis, laevibus, sphaericis, 8–85 μ, ovalibus, 7–20 × 10–35 μ, pyriformibus, 10–30 × 20–55 μ, fusiformibus, angularibus, vel irregularibus;

1–7 papillas exeuntes vel tubulis habentibis, 7–20 µ longitudine × 3–6 µ diam. ad infimo, quarum fines implantae sunt obturamento hyalino glutinoso, quod usque 4–10 µ supra verticem terminari potest. Rhizoidibus plerumque a pluribus locis in sporangiorum superficie emergentibus, principibus axibus plerumque crassis, diametrum, attingentibus 12 µ, maxime ramosis et extensis. Operculo hyalino, tenui, submerso in papillis exeuntibus vel tubulis, vadosis figura ad modum patellae vel crateris usque ad 6 µ diam., expulsis



FIGS. 34–42. *Karlingia hyalina.* 43–56. *K. rosea.*

et ablatis, zoosporis emergentibus. Zoosporis sphaericis, 4–5.5 μ, cum uno globulo refractivis hyalinis, 2–2.5 μ diam.; flagello 30–36 μ longitudine. Sporis perdurantibus ignota.

Saprophytic in decaying vegetable debris in moist soil, San Carlos, Matto Grosso, Brazil.

The organization, structure, and development of this species are so similar to those of *K. spinosa* and *K. rosea* that only the distinguishing structural characteristics will be noted here. Unlike all other known species of this genus, the zoöspores contain one large hyaline, glistening refractive globule, as is shown in figs. 34 to 36. These globules impart a different and characteristic refringent appearance to the mature sporangia also (FIG. 39). As in the previously described species, the zoöspores usually germinate extramatrically with one to several germ tubes (FIG. 38) which develop into the main rhizoid axes, while the zoöspore body becomes the sporangium. In exceptional and rare cases, however, the sporangia and rhizoids may develop intramatrically from a swelling near the tip of a branched germ tube (FIG. 37). This species is usually monocentric, but like *K. granulata* it rarely forms polycentric thalli with a large primary (FIG. 39A) and smaller secondary sporangium (FIG. 39B). So far, resting spores have not been found, and our knowledge of the life cycle of *K. hyalina* is incomplete in this respect.

In connection with the three new species described above it may be noted that the type species, *K. rosea,* also is abundant and widely distributed in Brazil. So far it has been found in all soil samples collected in the Amazon Valley. Its life history and development are too well known to merit further detailed description, but mention is made of it here to confirm the observation of Miss Johanson on the operculate character of the sporangia, and the behavior of the endoöpercula as the zoöspores are discharged, as well as to emphasize some of the variations which occurred in the Brazilian material. Particularly noteworthy is that the thalli, in exceptional cases, may become polycentric as in *K. granulata* and *K. hyalina.* Up to the present time only ten polycentric specimens have been found among the many thousands studied. Fig. 48 shows one of these specimens with a large central primary sporangium at X and secondary sporangia at Y and Z. The monocentric thalli also vary markedly in size. Thalli with spherical sporangia up to 450 μ in diameter have been observed. In contrast with these, minute sporangia (FIG. 49) which bear as few as four zoöspores often occur in the same substratum.

Another variation to be noted is that the thalli may sometimes develop partly intra- and extramatrically (FIG. 46) or completely intramatrically at the end of the penetration tube (FIG. 47) as in *K. spinosa* and *K. hyalina*. The latter type of development, however, appears to be very rare. When grass leaves, cellophane, and onion skin are used as substrata it is often difficult to determine whether the thalli are intra- or extramatrical, or partly so, particularly if the edges of the substrata are softened, disintegrating or covered with slime. Most investigators, however, have contended that *K. rosea* develops extramatrically with its zoösporangia arising directly from the zoöspore. The type of development and position of the thallus relative to its substratum can be readily determined if single cells are used as substrata. Individual cotton fibers are one-celled, tenuous, and usually smaller in diameter than the sporangia formed by *K. rosea,* so that if the latter are formed intramatrically the fibers become locally distended. Care should be taken to use only unprocessed fibers whose ends are sealed up and to avoid torn specimens so as to prevent entry of the zoöspores and their direct development intramatrically into zoösporangia. In cultures baited with carefully selected fibers, approximately 99 per cent of the sporangia were extramatrical and the remainder were intramatrical. In the latter class, a few empty zoöspore cases were found attached to the outside of the fibers and in contact with intramatrical thalli by a narrow penetration tube, as shown in fig. 47.

In this connection it should be noted that Haskins (3, 4) also found numerous thalli of *Rhizophlyctis petersenii* which had developed from the germ tube instead of from the zoöspore. However, the chytrid which he figured is probably *K. rosea* instead of *R. petersenii.* The latter species is chitinophilic, and we have isolated and grown it in culture on bits of purified chitin and chitin agar. It has not grown on cellophane as described by Haskins, nor does it produce a large number of exit tubes with plugs of opaque material. For these reasons we believe that Haskin's species is *K.*

rosea, and in that event our discovery of intramatrical thalli which developed from the germ tube confirms his observations.[1] We have frequently observed this type of development also in *Asterophlyctis sarcoptoides,* another monocentric, eucarpic chytrid, when it was grown in pure culture on strips of chitin or chitin agar, which indicates that it may be fairly widespread among chytrids.

Resting spores developed abundantly in cultures from soil samples collected at San Carlos, Matto Grosso, Porto Velho, Amazonas, and Manaus, Amazonas. They usually occur in groups on the surface of corn leaves and onion skin and in such cases are often clavate in shape. On the other hand, spherical, angular, elongate, oval and irregular spores are not uncommon in this species. While most of them are extramatrical, partly or completely intramatrical ones may occur rarely (FIGS. 50H, 54). In the latter event the empty zoöspore case may remain attached on the outside. So far as is known, the resting spores develop like the sporangia in the early stages but soon become filled with refractive material (FIG. 50F), and thick walled. While these changes are taking place, the protoplasm frequently contracts so that the mature spore often fills only a portion of the expanded thallus (FIG. 50G). In maturation the wall of the spores turns golden brown, and the refractive globules disperse until the content is coarsely granular (FIGS. 51–55). Figure 55 shows a thallus with two resting spores which were probably formed by the constriction, separation into two parts, and encystment of the sporeplasma. In germinating, the resting spores function as prosporangia and give rise to thin-walled zoösporangia (FIG. 56) as in the previously described species. However, in a large number of spores the contents grew out into contorted and fantastically-shaped vesicles which often continued to grow and enlarge until the protoplasm was completely used up.

The observation that the thallus of *Karlingia* may sometimes develop intramatrically at the end of a penetration tube shows that the type of development of this genus is not absolutely fixed and unvarying. In the majority of thalli the zoöspore body develops directly into the sporangium, while the germ tubes become the main rhizoidal axis. The determining factor in this method of development apparently is the position of the nucleus. If it remains in the zoöspore, the latter becomes the center of development and organization and develops into a sporangium. Sometimes, however, the intramatrical tip of the germ tube gives rise to the sporangium and rhizoidal system. In such cases the nucleus apparently passes into the germ tube so that the center of development is transferred from the zoöspore to the penetration tube. Although there are no cytological data on *Karlingia* to prove this point at present, it has been demonstrated in *Endochytrium* and *Cladochytrium* by Hillegas (5) and the author (7), respectively, that the type of organization and development is closely associated with the localization and distribution of the nuclei in the thallus.

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[1] Haskins (Trans. Brit. Mycol. Soc. 29: 138. 1946) has recently transferred this species to the genus Entophlyctis and named it *E. aurea.*

The discovery of occasional polycentric thalli in species which are predominantly monocentric indicates that this type of organization likewise is not absolutely fixed. The occurrence of reduced monocentric thalli in polycentric species is not uncommon, but the presence of polycentric specimens in monocentric species has been reported only for *Phlyctorhiza endogena* Hanson (2), *P. variabilis* Karling (11), and the species of *Karlingia* described above. Here also the transition from monocentric to polycentric thalli is quite probably dependent on the distribution and position of the nuclei. If one or several nuclei migrate out into the rhizoids of a monocentric species, become localized in a definite region, and divide, the rhizoid may enlarge locally and give rise to a secondary sporangium. This explanation is supported by the observation in *Cladochytrium replicatum* (7) that sporangia and resting spores develop only in regions of the rhizomycelium where the nuclei become localized and multiply.

SUMMARY

Three new chytrids, *Karlingia granulata, K. hyalina,* and *K. spinosa,* were isolated from soil samples collected in the Amazon Valley in Brazil and grown on various substrata which contain cellulose. They have the same type of development, organization, and structure as species of *Rhizophlyctis* but differ by the presence of exo- and endoöpercula in the sporangia. In *K. granulata* the

majority of opercula occur at the apices of exit papillae or tubes, but frequently the tips of the papillae deliquesce and the opercula are formed beneath. In the other two species, the tip of the exit tube always deliquesces and becomes filled with a plug of hyaline material, while the operculum develops underneath. *Karlingia granulata* is characterized by spherical zoöspores which contain numerous minute hyaline granules, and by smooth brown resting spores, whereas *K. spinosa* is distinguishable by spiny and verrucose resting spores and zoöspores with one to six golden globules. In *K. hyalina,* on the other hand, the zoöspores contain one large conspicuous hyaline refractive globule. In addition to these three species, *K. rosea* was found in all soil samples from Brazil. In all species except *K. spinosa* a few polycentric thalli were observed.

DEPARTMENT OF BOTANY,
COLUMBIA UNIVERSITY,
NEW YORK 27, NEW YORK

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EXPLANATION OF FIGURES

FIGS. 1–22, *Karlingia granulata*. FIGS. 23–33, *K. spinosa*. 1–3; spherical and amoeboid zoöspores containing numerous minute granules, × 1100. 4; large biflagellate zoöspore, × 1100. 5, 6; germination of zoöspores, × 1200. 7, 8; young thalli, × 1200. 9; mature spherical sporangium with three operculate exit papillae; rhizoids irregular and arising from several points on surface of sporangium, × 1400. 9A; primary operculum with jagged edge being pushed off by secondary operculum underneath, × 1500. 10; sporangium with two exoöperculate exit papillae, × 1400. 11; deliquescence of tip of exit papilla and the formation of an operculum beneath, × 1500. 11A; papilla with a small, low plug of opaque material, × 1500. 12; early stage of zoöspore discharge, × 1100. 13, 14; minute sporangia with endoöpercula, × 1200. 15; later stage of zoöspore discharge, × 1100. 16, 17; variations in size of opercula, × 1500. 18–21; stages in the development of resting spores, × 1100. 22; germination of resting spore, × 1100. 23–25; zoöspores containing one to six golden brown globules, × 1100. 26; extramatrical germination of zoöspore, × 1100. 27; young partly extra- and intramatrical thallus, × 1100. 28; young intramatrical thallus with attached zoöspore case and germ tube, × 1100. 29; young intramatrical spiny resting spore with attached zoöspore case and germ tube, × 1100. 30; diamond-shaped resting spore, × 1100. 31, 32; large spiny and elongate warty resting spores, × 1100. 33; surface view of spiny resting spore germinating, × 1100.

FIGS. 34–42, *Karlingia hyalina*. FIGS. 43–56, *K. rosea*. 34–36; spherical and amoeboid zoöspores with a large refringent globule, × 1100. 37; exceptional and rare intramatrical thallus developing at tip of germ tube, × 1100. 38; usual type of extramatrical thallus development, × 1100. 39; polycentric thallus with primary and secondary sporangia at A and B, × 1000. 40–42; variations in shape of opercula, × 1400. 43–44; spherical and oval zoöspores containing numerous minute granules, × 1100. 45; usual type of extramatrical thallus development, × 1100. 46; young partly intra- and extramatrical thallus, × 1100. 47; rare type of intramatrical thallus development, × 1100. 48; large polycentric thallus with primary sporangium at X and secondary sporangia at Y and Z, × 900. 48 A, B, C, D; successive stages of deliquescence of tip of exit tube, and formation of plug of opaque material and endoöperculum, × 1400. 49; minute monocentric thallus, × 1100. 50; young clavate resting spores on surface of substratum; rare intramatrical spore at H, × 1100. 51–53; irregular and spherical resting spores, × 1100. 54; rare intramatrical resting spore with attached zoospore case and germ tube, × 1100. 55; thallus with two resting spores, × 1100. 56; germination of resting spore, × 1100.

TAPHRINA OSMUNDAE NISHIDA AND TAPHRINA HIGGINSII SP. NOV.

A. J. Mix

(WITH 1 FIGURE)

An interesting feature of the genus *Taphrina* is the high state of development attained on ferns. About twenty species of this genus occur on ferns, seven of them having been described rather recently (2, 3). A few undescribed species are in the writer's possession and it is possible that additional forms may yet be discovered.

Although the clavate type of ascus prevails among fern-inhabiting species of *Taphrina,* as pointed out long ago by Giesenhagen (1), considerable variation in ascus-form exists. There is also marked variation in ascus-size, ranging from *Taphrina Hiratsukae* Nish. with asci 13–30 μ × 4–7 μ, stalk-cells 5–8 μ × 3–5 μ, to *T. lutescens* Rostr. with asci 27–75 μ × 6–11 μ (without stalk-cell). Asci with or without stalk-cells are well represented, the former by *Taphrina Hiratsukae* and other species, the latter by *T. filicina* Rostr. and at least one undescribed species.

Host-lesions vary from inconspicuous, unthickened leaf-spots, as in *T. Hiratsukae* and other species, to large galls, as in *T. californica* Mix, or very remarkable outgrowths, as in *T. cornu-cervi* Giesenhagen and *T. laurencia* Giesenhagen.

All three types of mycelial habit are exemplified by fern-inhabiting species of *Taphrina:* the subcuticular habit (*T. Hiratsukae,* etc.), the intercellular habit (*T. filicina,* etc.), and the habit of growing within the epidermal wall. In fact the "wall-habit" of mycelial growth, described by the writer for *T. amplians* Mix and other species (3), is known only in fern-inhabiting species and in two species occurring on Monocotyledons.

This paper is concerned with two species of *Taphrina* which seem to climax the series on ferns if not to form a connecting link between the genera *Taphrina* and *Taphridium.*

The first of these species is *Taphrina osmundae* Nishida. This fungus was described by Nishida in 1911 as causing yellow to brown, unthickened spots on leaves of *Osmunda regalis* L. It has been studied from the following specimens:

Taisenji, Pref. Tottori, Japan, July 1, 1924. K. Togashi.
Mt. Iwate, Pref. Iwate, Japan, June 13, 1934. K. Togashi.
Mt. Kirisama, Kyusu, Japan, May 29, 1938. I. Hino.

Yellow to brown unthickened spots occur on the leaves. These spots are variable in size, usually small, but sometimes involving a whole leaflet. A sparse white powdery layer of asci covers the lower surface of the spot and, less commonly, similar smaller areas can be seen on the upper surface.

Mycelium of the fungus grows within the outer epidermal wall, appearing, in the earliest stages seen, as septate hyphae of short segments, and sending (in some cases) unspecialized hyphal branches (haustoria) into the cell-cavity beneath (fig. 1; *A, B, D*).

Growth of the mycelium results in the hollowing out of a large locule in the cell wall with partial or complete obliteration of the cell cavity beneath (fig. 1, *C*). Shortly before ascus-formation each locule is seen to be occupied by a non-septate and multinucleate hyphal cell, entirely separate from similar cells in adjacent wall-locules. Whether this condition has been reached by loss of septa from the hyphae seen earlier, or by enlargement of individual cells of the young mycelium is not known.

Spore formation usually (though not always) begins before ascus-emergence and wall-locules may be seen containing numerous conidia. Ascospores have not been identified with certainty, though occasionally a few rounded uninucleate bodies have been seen, larger than the conidia, which may perhaps give rise to the latter by budding or by division. Spore formation occurs in a peripheral layer of protoplasm, leaving a large vacuole in the center of the cell.

The ascus emerges by rupturing the outer wall of the locule, appearing first as a small papilla, which gradually enlarges and assumes the shape of the mature ascus (fig. 1, *E, F, G*). As this process begins, it is seen that the hyphal cell occupying the wall-locule is enclosed in a definite thin membrane. At some time during or after emergence a septum forms across the basal portion of the ascus so that, at maturity, each ascus is provided with an empty stalk-cell. The stalk-cell is somewhat triangular in outline except that it is expanded into a foot which remains within the locule.

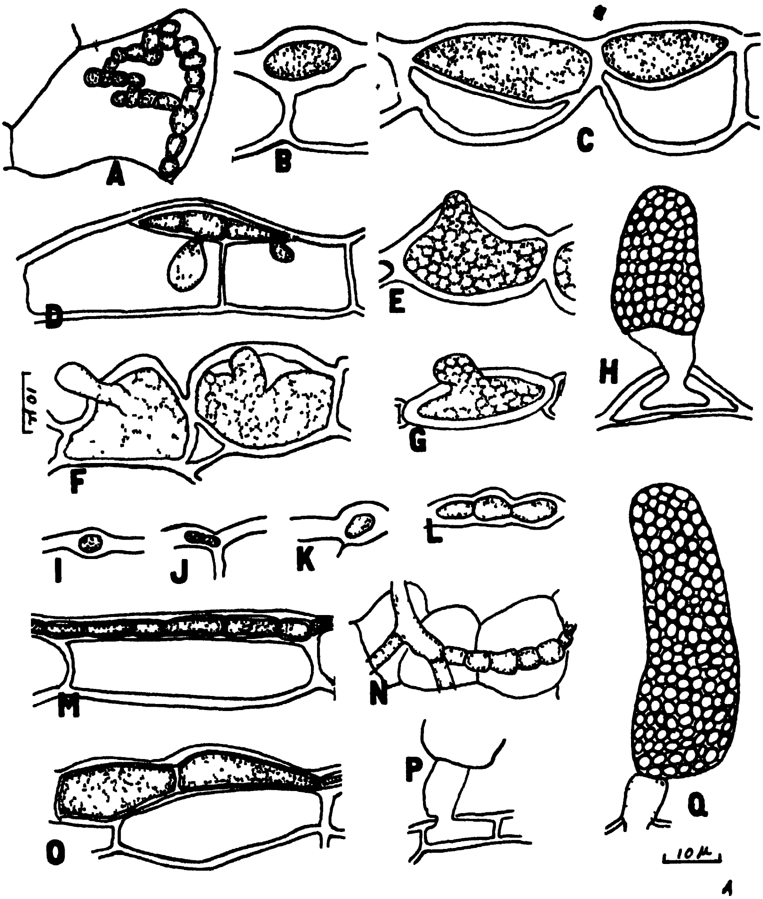

FIG. 1. Species of *Taphrina*.

The mature ascus (FIG. 1, *H*) contains a very large number of conidia, closely packed in a peripheral layer.

Dimensions are: Asci, 26–63 µ × 17–27 µ (average 42 × 21 µ); stalk-cells, 6–17 µ × 8–17 µ (average 9 × 16.6 µ); conidia 3–4 µ × 2–3.5 µ (average 3.6 × 3 µ).

The second fungus occurs on *Osmunda cinnamomea* L. It was collected at Pine Mountain, Blue Spring Farm, Hamilton, Georgia, May 26, 1938, by Dr. B. B. Higgins, who kindly sent material to the writer in October of the same year.

This fungus appears to have been collected earlier. Two packets of material are in the Herbarium of the Department of Plant Pathology, Cornell University, labelled as follows: "Curl of Osmunda cinnamomea, Botanical Dept. Cornell Univ. 9601 (Virginia Plants) Coll. by Wm. A. Murrill, Blacksburg, Va., June–Aug. 1897." The following has been added in another hand: "Taphrina filicina." This labelling appears to indicate that recognizable asci of a species of *Taphrina* were at some time present on the specimens. The leaf-spots are very like those on the Georgia material, but a careful search of the whole collection failed to reveal any asci. Microscopic examination showed a few epidermal wall-locules apparently containing mycelium, and it is highly probable that this is a collection of immature material of the fungus found in Georgia.

The Georgia fungus on *Osmunda cinnamomea* causes small, yellowish, unthickened leaf-spots, showing, when the fungus is mature, a sparse powdery layer of asci on the lower surface (and occasionally also on the upper surface).

In early stages septate mycelium may be observed in the outer epidermal wall (fig. 1, *I–N*). In a few cases haustoria have been observed. The mycelium enlarges, forming a wall-locule (fig. 1, *O*) in the same manner as *Taphrina osmundae*. The enlarged locule ultimately contains a multinucleate hyphal-unit in which conidia differentiate from a peripheral zone of protoplasm. This occurs before ascus-emergence. The ascus pushes out through the upper wall of the locule, appearing first as a small papilla. The mature ascus, containing numerous conidia closely packed against the ascus-wall (fig. 1, *Q*), is cut off by a septum from an empty stalk-cell. The free portion of the stalk-cell is cylindric and the basal portion, widened into a foot, remains within the wall-locule (fig. 1, *P*).

Since this fungus is morphologically different from *Taphrina osmundae*, it is herewith described as a new species, named in honor of its collector.

Taphrina Higginsii sp. nov.

Mycelium crescit in loculo quid format in muro externo epidermidis utraeque paginae foliae. Ascus unus emergit ex loculo. Asci sunt hypophylli aut amphigeni, oblongi, apice rotundati, 40–80 μ longi et 13–23 μ crassi. Cellula basilaris est cylindrata, angustior quam ascum, pedicellata, in loculo muri inserta. Ascosporae non visae sunt. Conidia numerosa sunt, 2–5 μ × 1.5–4 μ. Fungus efficit maculas parvas (usque ad 5 mm. diam.) flavas in foliis vivis *Osmundae cinnamomeae* L. Foliae non sunt deformatae. Blue Spring Farm, Pine Mountain, Hamilton, Georgia, May 26, 1938, B. B. Higgins.

Mycelium grows in a locule which it forms in the outer wall of the epidermis of each surface of the leaf. One ascus emerges from a locule. Asci are hypophyllous or amphigenous, oblong, rounded at the apex, 40–80 μ long and 13–23 μ broad (average 53 μ × 19 μ). The stalk-cell is cylindric, narrower than the ascus, 10–17 μ × 8–10 μ (average 12.5 μ × 9.6 μ). Ascospores have not been seen. Conidia are numerous, 2–5 μ × 1.5–4 μ. The fungus causes small (up to 5 mm. diam.) yellow spots on living leaves of *Osmunda cinnamomea* L.

Type material in the Mycological Herbarium, University of Kansas. Duplicate material in the herbarium of the Georgia Agricultural Experiment Station.

These two species of *Taphrina* seem to afford a climax to wall-inhabiting forms in that each wall-locule is occupied by a single multinucleate ascogenous cell, producing a single ascus. Since ascospores have not been seen, it is not impossible that spore formation may occur in the manner of the genus *Taphridium*. Species of *Taphridium,* however, besides being subepidermal in habit, produce a thick-walled chlamydospore whose endospore emerges to form the sporangium, whereas in *T. osmundae* and *T. Higginsii* the chlamydospore, if it can be so called, has a single membrane and the cell itself elongates to become the ascus.

Cytological study of these fungi is obviously needed. Fresh material of *T. Higginsii* was collected, in the type-locality, on May 26, 1941, but the fungus was immature, and only early stages of mycelial development were to be observed.

DEPARTMENT OF BOTANY,
UNIVERSITY OF KANSAS,
LAWRENCE, KANSAS

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EXPLANATION OF FIGURE

FIG. 1. *Taphrina osmundae*. *A–D*, development of mycelium within the epidermal wall; *A*, as seen from above; *B*, *C*, showing enlargement of wall-locule; and *D*, presence of haustoria. *E–G*, stages in emergence of asci. *H*, mature ascus showing stalk-cell and foot. *T. Higginsii*. *I–O*, development of mycelium in the wall and formation of locules. *P*, lower part of ascus showing stalk-cell and foot. *Q*, mature ascus.

NEW GENERA OF FUNGI. III *

ROLF SINGER

The present series of "New Genera of Fungi" deals exclusively with agarics. These genera, including one subgenus, are proposed in an effort to contribute to the revision of the generic taxonomy of these fungi, and they are based on certain atypical species that are not allied to anything now known within the existing genera. These are: *Pleurotus tessulatus* (Bull. ex Fr.) Gill., *Pleurotus japonicus* Kawamura, *Gymnopus praemultifolius* Murr., *Pleurotus porrigens* (Pers. ex Fr.) Gill and *Pleurotus lignatilis* (Pers. ex Fr.) Gill. (*sensu* Kühner), *Omphalia Postii* (Fr.) Karst. (*sensu* A. H. Smith) and *Clitocybe brevibasidiata* Sing., *Marasmius squamosidiscus* Murr., *Nolanea Strobilomyces* Murr., *Agaricus trisulphuratus* Berk., and also *Naucoria juruensis* Henn. Most of these species have been described in or transferred to several genera, or are completely out of place in the genus to which they have been referred in the literature. This is not unexpected since they did not resemble the types of their respective genera very closely in the first place, and their position had been determined mainly or exclusively on the basis of macroscopical characters. The writer has studied their macroscopical, microscopical, and chemical characters, and since these were found to be in disaccord with the characters of the established genera, new generic names had to be proposed for them.

1. **Hypsizygus** Sing. gen. nov.

Tricholomatacearum genus; carpophoro pigmento fere destituto, clitocybeo-tricholomatoideo atque pleurotoideo; mycelio ad ramos arborum ascendente, haud luminescente, albo; pileo sicco, saepe rimoso-areolato; cuticula ex hyphis repentibus filiformibus, levibus consistente, aegre differentiata; lamellis adnexis vel adnatis, neque decurrentibus nisi dente inconstante, nec profunde sinuatis neque emarginatis nisi in uno latere carpophororum paucorum; spo-

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* The first part of this series appeared in MYCOLOGIA 36: 358–368. 1944; the second part in *Lloydia* 8: 139–144. 1945.

ris in cumulo albis, globosis vel subglobosis, levibus, inamyloideis, membrana simplici, dein subincrassata institutis, parvulis; basidiis granulatione carminophila destitutis; cystidiis et cheilocystidiis nullis; tramate lamellarum regulari, ex hyphis *Clitocybarum* modo dispositis efformato; subhymenio perangusto, filamentoso-intertexto-ramoso; stipite saepe curvato vel subexcentrico, evelato, firmo, solido; carne haud revivescente, ex hyphis inamyloideis, fibuligeris consistente. Ad truncos ramosque vivos arborum frondosarum.

The type species is **H. tessulatus** (Bull. ex Fr.) Sing. comb. nov. [*Pleurotus tessulatus* (Bull. ex Fr.) Gill.] This is what is called *Pleurotus ulmarius* by all American authors. The true *Pleurotus ulmarius* of Europe, *i.e.*, the species now generally considered to be that species by recent European mycologists, has rightly been transferred to *Lyophyllum* Karst. em. Sing. because of its basidia which show a distinct carminophilous granulation (the most constant and reliable character of the genus *Lyophyllum* and two other closely related genera). The American species has ordinary basidia without any carminophilous granulation in any stage of development. It must, therefore, be different from the European *Pleurotus* or rather *Lyophyllum ulmarium*, at least in the sense of the modern authors. Since the American species has all the characters of *Pleurotus tessulatus* such as shown in the descriptions of Fries, the figure of Bulliard, and the few specimens in the herbaria so determined, we think that this specific epithet should be transferred to a new generic name based on the plant as described by the American authors under the name of *Pleurotus ulmarius*.

Hypsizygus is close to *Clitocybe, Tricholoma, Omphalotus,* and *Pleurocybella* (see under no. 4).

Clitocybe differs in adnato-decurrent or deeply decurrent lamellae which is one of the basic characters of that genus; also in the fact that the spore walls in *Clitocybe* remain thin to extremely thin, and have no tendency to become somewhat thick as in *Hypsizygus;* besides their shape is rather unusual in *Clitocybe,* at least among the smooth-spored species. The parasitic habit of *Hypsizygus* has no parallel among the Clitocybes where lignicolous species are a small minority, and these always grow on very decayed wood near the ground, not high up on the branches or in the wounds of the trunk as does *Hypsizygus.*

Tricholoma differs from *Hypsizygus* in the absence of clamp connections, as far as the majority of the species is concerned; only a few have clamp connections (sect. *Rigida*), and these do not seem particularly close to *Hypsizygus*. They differ in their characteristic and constant emarginate-sinuose attachment of the lamellae to the stipe, in extremely thin to thin spore walls, in different spore shape, and in their humicolous habit as saprophytes in and outside the woods.

The frequently eccentric stipe and the parasitic growth on living trees has naturally induced the older mycologists to consider this species as a *Pleurotus*. However, *Pleurotus* is a collective genus, and what now is considered as *Pleurotus sensu stricto* is quite different from *Hypsizygus*, so different it can hardly be called related at all. The irregular trama, the decurrent lamellae, the cheilocystidia, the frequently colored, cylindric spores and the broad, well differentiated subhymenium of *Pleurotus* are only a few characters that readily separate it from *Hypsizygus*. *Omphalotus*, one of the groups split from *Pleurotus*, based on *Pleurotus olearius*, has the spores more like those of *Hypsizygus*, but the abundant and peculiar pigment, the strange cystidiform sterile bodies of the hymenium, the strongly decurrent lamellae, the luminescence and the more irregular structure of the trama separate it from *Hypsizygus*. *Lentinus* differs because of its reviving quality due to the thick walled hyphae, and—more important—because of the cylindric spores that put it in the tribe made up by *Pleurotus, Lentinus, Panus, Asterotus, Anthracophyllum* and *Phyllotopsis* rather than in the tribe Clitocybeae where *Hypsizygus* undoubtedly belongs.

We therefore propose a new genus, emphasizing its habitat in its name. There are probably other species belonging here, *e.g.* *Clitocybe circinata* (Fr.) Karst. sensu Sing. (1943) which is very close to *H. tessulatus*.

2. **Lampteromyces** Sing. gen. nov.

Tricholomatacearum genus; carpophoris pleurotoideis, luminescentibus; pileo fibrilloso, haud viscoso; lamellis profunde decurrentibus; basidiis haud granulosis in solutione acetocarminica; sporis hyalinis, giganteis, globosis, inamyloideis (nec pseudoamyloideis), levibus, membrana saepe crassiuscula instructis, in cumulo albidolilascentibus; cystidiis cheilocystidiisque indistinctis vel nullis; tramate lamellarum regulari, ex hyphis subflexuosis vel strictis, hyalinis, haud dense intertextis consistente; subhymenio angusto; stipite excentrico vel laterali, firmo-tenaci, distincte annulato e velo persistente quod ex hyphis filamentosis constat; carne ex hyphis inamyloideis, fibuligeris consistente. Ad ligna.

This genus is based on *Pleurotus japonicus* Kawamura, *Journ. Coll. Sci. Imp. Univ. Tokyo* 35(3): 2. 1915, which was transferred to *Armillaria* by Imai, and is now renamed **Lampteromyces japonicus** (Kawamura) Sing. comb. nov. It was temporarily admitted in *Pleurotus* as a separate section by the present writer, but a personal examination of specimens[1] shows that it is not merely the shape of the spores that separates this species from *Pleurotus* but the structure of the trama which is irregular-subintermixed in *Pleurotus,* and the structure of the subhymenium which is a broad, well differentiated layer in *Pleurotus.* Adding such chemical-physiological characters as the presence of a poisonous and a luminescent substance (hence the name *Lampteromyces* = lantern fungus) one is convinced that *Lampteromyces* is generically different from *Pleurotus.* It appears to be an abundantly characterized genus, probably close to *Laccaria* which differs by the either elongate or echinate spores, the central stipe and the lack of a veil, also by the lack of a poisonous and a luminescent substance, and by its usually non-lignicolous habit.

3. **Pleurocollybia** Sing. gen. nov.

Tricholomatacearum genus; carpophoris abundanter pigmentatis, collybioideo-pleurotoideis; pileo glabro, hygrophano, tenui, depresso vel umbonato, ellipsoideo vel circulari; epicute ex hyphis horizontalibus, filamentosis consistente, dermatocystidiis destituta; lamellis adnexis vel subsinuato-adnatis, densis, tenuibus; sporis in cumulo pure albis, minutis, inamyloideis (nec pseudoamyloideis), levibus, subglobosis; basidiis granulatione carminophila destitutis, tetrasporis; cystidiis cheilocystidiisque nullis, tramate lamellarum regulari, ex hyphis subparallelis vel parallelis, pro ratione latis sed satis elongatis, moderate tenui-tunicatis consistente, tenui (25–45 μ in diametro); subhymenio ex elementis parvulis efformato, bene delimitato, cellulari; stipite excentrico, saepe obliquo, tenuiculo, spongioso-farcto, evelato; carne plus minusve amara, ex hyphis inamyloideis, haud fibuligeris consistente. Ad ligna putrida.

The type is **Pleurocollybia praemultifolia***(Murr.) Sing. comb. nov. (*Collybia praemultifolia* Murr. and *Gymnopus praemultifolius* Murr., *Proc. Florida Acad.* 7: 129, 107. 1945).

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[1] The writer is indebted to the Headquarters of the U. S. Army in Japan, for kindly forwarding specimens of this fungus to this laboratory.

It differs strongly from *Collybia* in the eccentric pileus (hence the generic name) and—more important—the clampless hyphae, also in the very minute spores (2.7–3.5 × 2.5–3.2 μ). It is more closely related to *Podabrella* Sing. and *Callistosporium* Sing., differing from the former in the pure white spore print and abundant pigmentation, also in being eccentrically stipitate and extremely small spored, and from *Callistosporium* in the lack of the bright colored pigment bodies in the hyphae, basidia, and spores, also in being eccentrically stipitate, and in the subglobose, minute spores. The type of the genus has been studied by the writer in Gainesville, and the specimens collected by him personally in South Florida have been compared and found to be identical. This is a well characterized genus which, in spite of being monotypic, is separated from its relatives by a wide hiatus.

4. **Pleurocybella** Sing. gen. nov.

Tricholomatacearum genus; carpophoris haud pigmentatis, pleurotoideis; pileo glabro; epicute paulum differentiata, haud gelatinosa; lamellis adnato-subdecurrentibus vel attenuatis concurrentibusque; sporis in cumulo albis, hyalinis, subglobosis vel ellipsoideis, tenuitunicatis, inamyloideis (nec pseudoamyloideis), minutis; basidiis minutis, granulatione carminophila destitutis, tetrasporis; cystidiis cheilocystidiisque nullis; tramate lamellarum irregulari, subintermixto vel intermixto, ex hyphis tenuitunicatis, dein subcrassotunicatis (0.5–1.0 μ vel plus), nonnulis interdum per hymenium rumpentibus crines hyphales cystidiformes efformantibus, inaequalibus nec parallelis consistente; stipite nullo vel excentrico; velo nullo; carne carnoso-subtenacella vel carnoso-submolli, ex hyphis membranis subincrassatis institutis, inamyloideis, fibuligeris consistente. Ad ligna.

The type of the genus is **Pleurocybella porrigens** (Pers. ex Fr.) Sing. comb. nov. = *Pleurotus porrigens* (Pers. ex. Fr.) Gill. This species is not a *Pleurotus* in the present sense, considering its short spores and the lack of a strongly limited subhymenium. The writer has temporarily considered it as a species of the genus *Scytinotopsis* but this later genus, though it has the short spores of *Pleurocybella,* is nevertheless different. At least a portion of the trama of the pileus is gelatinized in *Scytinotopsis,* and the mediostratum of the trama of the lamellae is regular; the cuticle is more differentiated, and is strongly pigmented. It appears that *Scytinotopsis* (or rather *Resupinatus* S. F. Gray since Gray's work has been shown to be post-Friesian) is closely related to *Geopetalum* (= *Acanthocystis*) whereas *Pleurocybella* is closely related to *Clitocybe* and *Hypsizygus,* and perhaps nearest to *Nothopanus. Clitocybe* differs in the central stipe, the decurrent lamellae, the structure of the trama of the lamellae which is never as strongly irregular as it is in *Pleurocybella. Hypsizygus* differs in regular gill trama, and the spores that become thick-walled, also in much broader lamellae which are attached to a stipe but not adnate-subdecurrent. As for *Nothopanus,* we at first attempted to emend that genus in order to incorporate *Pleurocybella,* because there is no doubt in our mind that *Pleurocybella* represents the boreal group, and *Nothopanus* the tropical group of fungi with a common ancestry. Yet, the gap between them is too great, and the species belonging to *Pleurocybella* too dissimilar externally from those belonging to *Nothopanus* to be combined into a single genus. *Nothopanus* has a reviving trama if dried out *in situ* and remoistened, the lamellae are broad, especially if compared with the diameter of the context, and distant; the surface of the pileus is radiately fibrillose and usually pigmented (excepting some occasional specimens of *N. eugrammus*). *Pleurocybella* has a putrescent trama, the lamellae are rather narrow to very narrow, and remarkably crowded in the type species; the surface is not fibrillose and no more pigmented than the rest of the carpophore. In addition,.the type species has a slight odor of *Collybia dryophila* or cyanic acid (which it actually discharges in fresh condition) whereas the *Nothopani* are completely odorless.

A second species which is probably congeneric with *Pleurocybella porrigens,* is *Pleurotus lignatilis* (Pers. ex Fr.) Gill. *sensu* Kühner, This may appear surprising at first glance—if the well developed, eccentric stipe is taken into consideration. However, this is, macroscopically, the only character that does not agree perfectly with the other important characters of the type species of *Pleurocybella,* and microscopically, these species are extremely similar, except for the slightly more elongate spores of *P. lignatilis.* Kühner states that this species constitutes "un type à part . . . qui mériterait d'être séparé" [from *Pleurotus*]. It has generally been taken for a *Clitocybe* in recent taxonomic papers (Heim & Romagnesi, Singer), yet it differs in the structure of the trama, thick walls of the tramal hyphae, the eccentric stipe and the less decurrent lamellae. One will notice that these are precisely the characters by which *Pleurocybella porrigens* differs from *Clitocybe*.

5. *Omphalina* subgenus **Romagnesia** Sing. subgen. nov.

Tricholomatacearum subgenus; carpophoris hygrophoroideo-omphalioideo, pigmento abundante flavo *Omphalotum* et *Gymnopilos* in mentem revocante imbutis quando sub microscopio examinata sunt; pileo dein infundibuliformi, glabro, hygrophano, diaphano; epicute ex hyphis intertextis, repentibus, filamentosis consistente; lamellis tenuibus, decurrentibus; stipite farcto, centrali, moderate tenui, evelato; sporis in cumulo albis, levibus, ellipsoideus, inamyloideis (nec pseudoamyloideis); basidiis tetrasporis, granulatione carminophila destitutis; cystidiis raro obviis, clavatis, inconspicuis, vel nullis; tramate lamellarum angustissimo, regularissimo, ex hyphis filamentosis, hyalinis, tenuibus, parallelis efformato, tertiam modo partem spatii inter hymenia occupante; subhymenio quoque tertiam partem eius spatii occupante, id est summa amborum subhymeniorum duas tertias spatii interni occupantibus, hyalino, irregulari-intermixto; stipite centrali, farcto, evelato, tenui sed haud cartilagineo; carne ex hyphis tenuitunicatis, fibuligeris vel haud fibuligeris, inamyloideis constituta. Ad (vel inter) Bryophyta.

The type species, **Omphalina Postii** (Fr. *sensu* A. H. Smith) Sing. comb. nov. = *Omphalia Postii* (Fr.) Karst. *sensu* A. H. Smith is not a true *Omphalina*.[2] Its very peculiar pigment, dissolved and yellow, and coloring the whole preparation yellow, as is also the case in *Omphalotus olearius, Gymnopilus sapineus,* and the hymenophore of *Pulveroboletus auriporus,* differs strongly from the dusky incrusting pigment of *Omphalina;* the trama is very different, its elements are more thick-walled, irregularly arranged and the trama much broader in relation to the subhymenium; the lamellae are more distant, and the habitat more varied. Searching for a genus where *O. Postii* could be classified we have also thought it possible that this species is a *Hygrocybe* rather than a tricholomataceous plant. However, the size of the basidia and the structure of the trama do not in the least justify the suspicions which are brought about by the orange color that is reminiscent of *Hygrocybe Cantharellus* (Schw.) Lange. However, this color also reminds one of another genus, *Hemimycena,* where several species, among them the common *H. fibula,* are as orange as *O. Postii.* A careful comparison of the structure of the trama of all these species with the trama of *O. Postii* revealed that the structure found in *O. Postii* does not occur in *Hemimycena.* Aside from this, the *Hemimycenae* differ in other characters, *e.g.,* the presence of cystidia or cheilocystidia, the constant presence, in four-spored forms, of clamp connections, the epicutis made up of diverticulate hyphae or dermatocystidia, etc. It is hard to tell whether or not the similarity of the color means anything phylogenetically (it has certainly influenced Fayod's opinion), but it is obvious that *Hygrocybe, Omphalina Postii,* and the orange species of *Hemimycena* (or perhaps rather *Marasmiellus*[3]) are not congeneric.

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[2] The generic name *Omphalia* (Fr.) Quél. cannot be retained because S. F. Gray took up Persoon's sectional name *Omphalia* as a genus in 1821, and this status is valid since Gray's books are post-Friesian. It thus has priority over *Omphalia* (Fr.) Quél. which is not identical. The latter can, however, easily be replaced by *Omphalina* Quél.

This genus is also different from *Clitocybe,* because of the structure of the trama and because of the frequent occurrence of constantly clampless forms which are never observed in *Clitocybe,* and finally because of the characteristic pigment that is never found in *Clitocybe.* Not knowing about the existence of clampless forms in *Romagnesia,* the author has described a new species of this same group in *Clitocybe* under the name of *Clitocybe brevibasidiata* Sing. This Central-Asiatic species should now be known as **Omphalina brevibasidiata** (Sing.) Sing. comb. nov. It differs from *O. Postii* (Fr.) Sing. in the presence of clamp connections. The genus *Omphalotus* Fayod has the same pigment as *Romagnesia* (at least microscopically), yet the much more irregular trama, the fasciculate, lignicolous habit, its poisonous and luminescent properties, and the much fleshier, robust carpophores make it impossible to consider a generic identity of these genera.

The name *Romagnesia* has been selected in view of the valuable data on *Omphalia* and the affinities of this genus, published by our distinguished French colleague Henri Romagnesi.

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[3] The type of *Marasmiellus juniperinus* Murr. has been studied by the writer, and it appears that this species belongs to *Hemimycena* (near the *Rameales*-group). Since Murrill has designated this species as the type species of the genus *Marasmiellus* it now becomes necessary to replace the generic name *Hemimycena* Sing. by Murrill's name, and place *Hemimycena* in the synonymy of *Marasmiellus.*

6. **Ripartitella** Sing. gen. nov.

Leucocoprinacearum genus; carpophoris pluteoideo-pleurotoideis, pigmento membranali praeditis; pileo squamuloso, squamulis e catenulis elementorum hyphalium breviusculorum haud sphaerocystiformium constantibus; lamellis adnatis vel subliberis; sporis in massa albis, hyalinis, minutis, subglobosis, echinulatis, inamyloideis et numquam pseudoamyloideis; basidiis normalibus familiae; cystidiis ventricosis in parte inferiore, sagittatis vel tenui-palatis crystalliferis *Melanoleucarum* modo in parte superiore, ad latera et prope aciem lamellarum dispersis; tramate subregulari, dein subirregulari, ex hyphis neque intermixtis neque parallelis consistente; stipite excentrico vel centrali, velato sed vix persistenter annulato; carne ex hyphis haud amyloideis, fibuligeris consistente. Ad ligna, raro ad terram humosam.

The type with its synonymy has been described in the writer's "Type Studies on Agarics II" (*Lloydia* 9: 128. 1946); it is *Ripartitella squamosidisca* (Murr.) Sing. It occurs from Florida south to southern Brazil. It is very similar to *Ripartites* microscopically, and as far as **Ripartites strigiceps** (Fr.) Sing. comb. nov. (*Agaricus strigiceps* Fr.) is concerned, it resembles it to a certain degree, even macroscopically. However, we do not think that the two genera are actually closely allied. On the contrary, it appears that they belong to different families, *Ripartitella* being obviously closely related to *Cystoderma* because of the way its lamellae are attached to the stipe, and because of the similarity of the cystidia of *Ripartitella squamosodisca* with those of *Cystoderma cinnabarinum,* and also because of the short hyphae making up the scales of the pileus. The two genera differ, however, in three important characters: (1) the structure of the covering layer of the pileus and stipe which is an epithelium in *Cystoderma,* and a trichodermium in *Ripartitella;* (2) the wall of the spores which is always smooth in *Cystoderma* whereas it is echinulate in *Ripartitella;* (3) the eccentric position of the stipe in a large number of carpophores of the *Ripartitella* whereas *Cystoderma* is centrally stipitate.as the rest of the Leucocoprinaceae.

7. **Cystoagaricus** Sing. gen. nov.

Leucocoprinacearum genus; carpophoris minoribus lepiotoideis, pigmento plerumque incrustante membranas hypharum, obscuro vel laetissimo; pileo elato vel applanato, furfuraceo vel squarroso-spinoso; epicute velum universale praesentante, e corpusculis furfuraceis vel pilosis consistente, quae epithelio pseudoparenchymatico vel catenulis, quarum elementa sphaerocystoidea (globosa vel ellipsoidea) sunt, efformantur; lamellis liberis vel adnexo-subliberis, ascendentibus vel subhorizontalibus, latiusculis; sporis in massa subpurpureo-fuscis, sub microscopio obscure brunneo-fuscis vel purpureo-fuscis, KOH ope interdum subolivascentibus, minoribus (10 μ longitudine haud attingentibus), membrana duplica, iodi ope haud mutata, levi, primo hyalina, dein obscure colorata, ad porum germinativum indistinctum vel distinctum saepe truncatum interrupta instructis, circumferentia curvata vel angulato-nodulosa gaudentibus, reniformibus vel polyedricis inaequilateralibusque, saepe noduloso-undulosis et frequenter vel semper parte hilari excessive protracta nodiformi, subelongatis vel subisodiametricis; basidiis normalibus minusculis, latiusculis, tetrasporis; cystidiis ad latera lamellarum nullis; cheilocystidiis praesentibus, in typo pluricellularibus, e catenulis elementorum vesiculosorum, latissimorum consistentibus, ex iis acie lamellarum heteromorpha; tramate regulari, ex hyphis subvoluminosis consistente; stipite squarruloso vel e velo generali furfuraceo saepeque annulato; tegumento stipitis ei pilei analogo; carne tenui vel media; hyphis fibuligeris; ad ligna et in arena humosa.

The type species is **Cystoagaricus Strobilomyces** (Murr.) Sing. comb. nov. (= *Nolanea Strobilomyces* Murr., Fla. Acad. Sci. **7**: 118. 1944, published 1945) which has been collected in 1938 by W. A. Murrill in Alachua County, and by the author in 1942 in Dade County, Florida. I noticed the outstanding characters of this fungus immediately after collecting, but since I found the same plant in the unpublished material prepared by Dr. Murrill at Gainesville, Fla., I waited for its publication which did not come forth until 1945, and then in a genus that has definitely not the slightest affinity to the species in question. We must, therefore, transfer this species—but in order to transfer it to the proper genus, a new generic name had to be adopted.

The difficulty here is not the separation of this new genus from existing genera. The shape of the spores, combined with the structure of the edge of the lamellae and the epicutis, the subfree lamellae which are ventricose, even when ascendant, and the dark color of the spores make it impossible to consider its generic identity with *Inocybe, Deconica, Stropharia,* or *Psathyrella,* and the combination of these correlated characters separates it clearly from *Agaricus* and all other genera of the Leucocoprinaceae in which family it belongs much rather than in the Strophariaceae, or Coprinaceae.

This view is confirmed by the examination of a second species that evidently belongs in *Cystoagaricus, viz.,* a fungus collected by D. H. Linder in Liberia, and given to me for determination. Though we have not seen the type of *Agaricus trisulphuratus* Berk., we think that it is this species. Here, the covering of the pileus is rather furfuraceous and separable, consisting of an epithelium, and colored brightly rather than dark, and the veil is more distinct, the size larger, and the habitat probably on sandy soil rather than on wood. We propose the new combination **Cystoagaricus trisulphuratus** (Berk.) Sing.

The less constantly angular spores which have a more typical *Agaricus*-color in KOH, and the more *Agaricus*-like external appearance of this plant which was consequently also considered as belonging in *Agaricus* by Berkeley when he described the type specimens from Zanzibar, Africa, also the more distinct veil, the larger size, the habitat, all tend to make the gap between *Cystoagaricus* and *Agaricus* appear to be smaller than it might appear if only *C. Strobilomyces* were known.

In both species, we sometimes observe a phenomenon that is not rare in some groups, namely, the formation of twin spores held together by a common thin perisporium.

In order not to be responsible for a duplication of names, we have taken great care to find out what the genus *Micropsalliota* Höhnel represents. In spite of the general belief that this designates small species of *Agaricus,* we found all the specimens available in the Höhnel Herbarium (Farlow Herbarium) different from *Agaricus* by paler spores which are pseudoamyloid. These species, especially the type species of the genus, fit perfectly into the sections established in *Lepiota;* they differ merely by the slightly colored spores, a character quite common in *Lepiota.* They should be transferred to *Lepiota,* and the genus *Micropsalliota* should be placed in synonymy.

We have also compared the species of the genus *Phaeomarasmius* in its original limits as well as in the limits as broadened by Romagnesi. These species often have an epithelium-like epicutis, or catenulate spherocysts, yet the spores are definitely not of the color seen in *Cystoagaricus,* not to mention their shape. We have previously considered some of the *Phaeomarasmii sensu lato* as belonging to *Naucoria* but it appears that Romagnesi is probably right in referring the non-hygrophanous species to *Phaeomarasmius.* Nevertheless—*Naucoria* can easily be separated from *Cystoagaricus* by the color (rather sordid-brownish) and shape (reniform to subamygdaliform) of the spores and the different shape of the cheilocystidia. The similarity—macro- and microscopical—between *Cystoagaricus Strobilomyces* (Murr.) Sing. and some *Naucoriae* or *Phaeomarasmii* is therefore purely superficial, and does not indicate any affinity.

The genus *Nolanea* is much rather a subgenus of the genus *Rhodophyllus* than an independent genus. In any case, the spores of *Nolanea,* though angular, are of a different shape, an entirely different color (pink rather than purplish-fuscous); the basidia are much larger and not so broad as in *Cystoagaricus;* the *Nolaneae* never show a combination of anatomical characters as found in *Cystoagaricus,* and are always naked (without veil). *Nolanea* (*Rhodophyllus*) and *Cystoagaricus* are not related.

In *Psathyrella,* the lamellae are more broadly adnate, and a combination of a pseudoparenchymatic general veil and septate cheilocystidia of a vesiculose type is never found in that genus; in some species, the spores may appear somewhat angular but they are still different in shape. In the writer's opinion, *Cystoagaricus* and *Psathyrella* are related only insofar as the families to which they belong (Leucocoprinaceae and Coprinaceae) are related with each other.

8. *Conocybe* Fayod, subgenus **Ochromarasmius** Sing. subgen. nov.

A sectionibus generis *Conocybis* omnibus differt sporis minutis, distincte verrucosis stipiteque tenuissimo, cartilagineo. Ad truncos putridos caespitose in Brasilia.

The type species of this new subgenus is *Naucoria juruensis* Henn. the type of which has surprisingly small (4–5.8 × 2.8–3.5 μ), rusty colored, warty spores which usually show a small germ pore at the apex. The stipe reminds one of that of some small *Marasmii* like *M. aciculiformis* B. & C. of the section *Hygrometrici* Kuhn. It is covered with dermatocystidia of the capitate type as found on the stipe of *Conocybe tenera* sensu Kuhner and related species; these dermatocystidia are hyaline to chestnut colored, and measure

17–19 × 7.5–8.8 μ, the capitulum being 4.2–5.2 μ in diameter. Some of the dermatocystidia, however, are devoid of a capitulum, and are merely broadly ellipsoid, or mucronate. These bodies cause the pruina mentioned by Hennings. This species is certainly not close to *Phaeomarasmius* as implied by Hennings, in spite of the fact that the name *Phaeomarasmius* would perhaps fit our new subgenus better than the genus that is now rightly known as *Phaeomarasmius*. We have therefore chosen a name indicating the spore color (and affinity) of the subgenus in a combination with the old name *Marasmius*, thus making reference to the characters due to adaptation (thin, cartilaginous stipe).

We contrast the new subgenus *Ochromarasmius* to the subgenus **Euconocybe** Sing. subgen. nov. based on the type species of *Conocybe*, and characterized by a thicker, very fragile stipe, and spores that are never at the same time minute and warty.

FARLOW HERBARIUM,
HARVARD UNIVERSITY,
CAMBRIDGE, MASS.

NOTES ON THE TREMELLALES OF GEORGIA

Lindsay S. Olive

(with 16 figures)

The specimens described here were collected by the writer in the vicinity of Athens, Georgia, during the fall, winter, and spring of 1945–1946. The majority of the thirty-four species listed have not been previously reported from this state. A species of *Platygloea,* apparently not reported since its discovery in Europe, has been found and is redescribed here. A single new species is proposed under the generic name *Seismosarca.* Undoubtedly, a much larger number of tremellaceous species will be found as the survey is extended to other parts of this state, which is characterized by an interesting succession of climatic, topographical, and vegetative zones.

Excellent keys to the identification of most of the Tremellales discovered in this country will be found in a recent publication by Martin (1944) and in an earlier paper by Coker (1920). Martin's paper also presents a very helpful bibliography on the taxonomy of the Tremellales of North America.

Auricularia auricularis (S. F. Gray) Martin. Amer. Midl. Nat. 30: 81. 1943.

Fructifications were found growing on hickory limbs lying on the ground. They are typical in appearance and texture, but I have found that the range in size of spores is slightly greater than that given by Martin or Coker. They measure 4.9–6.5 × 11.7–17.6 μ. Only three collections of it were made in this area.

Growing on corticate and decorticate hickory limbs, Athens, Georgia. November–December, 1945.

Platygloea peniophorae Bourd. & Galz. Bull. Soc. Myc. Fr. 25: 17. 1909. (fig. 3.)

The fungus was found growing entirely within the fructifications of a small species of *Dacrymyces.* It is characterized by hyphae with conspicuous clamp connections, narrow haustorial branches which are frequently found applied to the hyphae of the host, and conidiophores that produce obovate or oval conidia which measure 3.3–4.6 × 5–9.8(12.4) μ. Clamp connections often occur at the bases of the conidiophores. Moreover, each conidium appears to develop with a clamp connection at its base. After several conidia have been shed, an equal number of clamp connections may be observed on the upper parts of the conidiophores, as shown in the figures. The basidia are four-celled, often with a stalk cell at the base, measuring 5–6 × 32–46 μ. Basidiospores are ovate, apiculate, and slightly flattened on one side, and measure 4.6–5.9 × 7.2–9.4 μ.

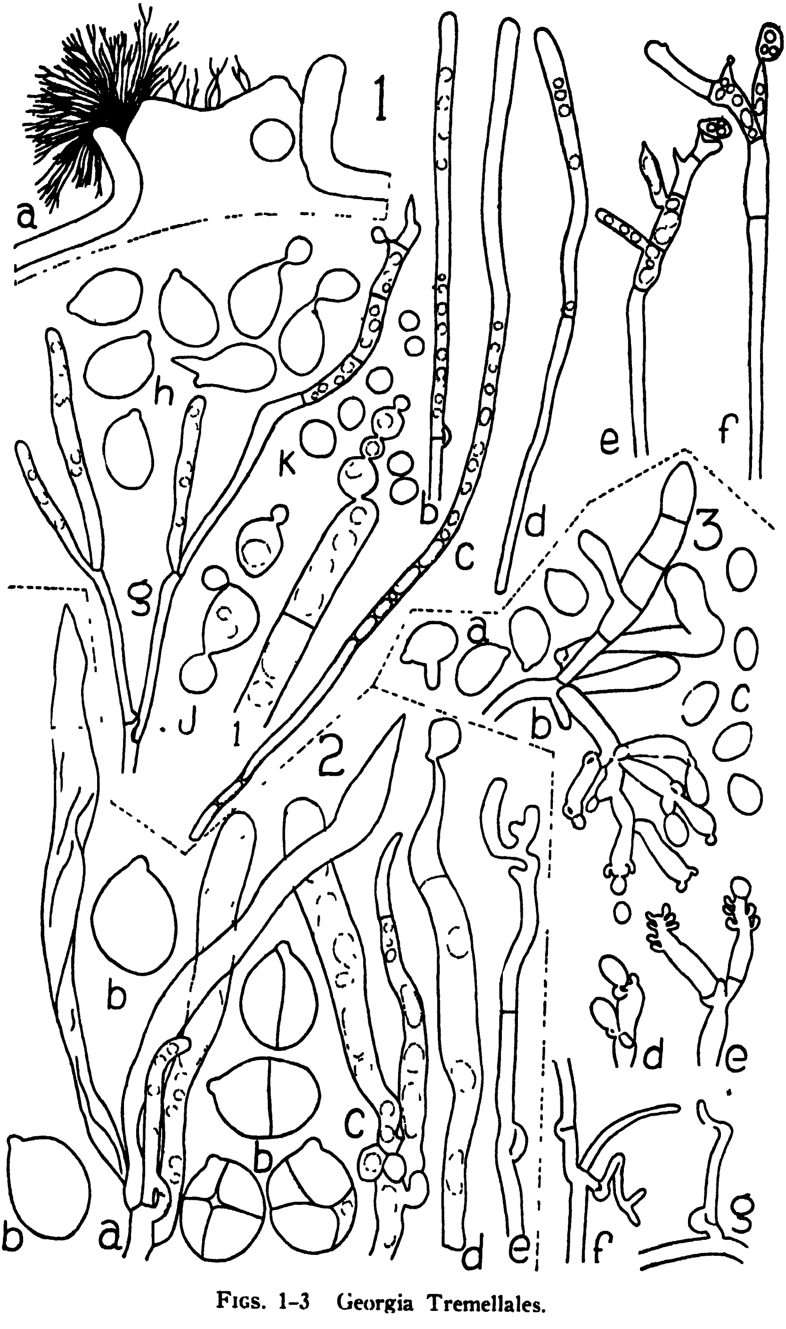
This same fungus was reported by me earlier from North Carolina (1946), where it was found parasitizing a *Dacrymyces*. The species, as noted previously by Martin (1940), shows considerable variation in the size of its basidia and basidiospores. The specimens which I have collected also show a great deal of variation in size of conidia.

Growing within the fructifications of *Dacrymyces* sp., Athens, Georgia. April 11, 1946.

PLATYGLOEA MIEDZYRZECENSIS Bres. Annal. Myc. 1: 113. 1903. (FIG. 1.)

Bresadola described this species from a collection made in Poland, and there has probably been no other report of it since then. I have examined a part of the Bresadola collection and find it very much like the Georgia collection in general appearance. Moreover, the microscopic characters of the two are considerably alike. The Georgia collection is described as follows:

Fructifications white, very soft, gelatinous, pulvinate, erumpent, anastomosing, surface smooth, individual pustules measuring 0.5–2.5 mm. (Bresadola: 2–4 mm.) in diameter, not exceeding 0.6 mm. in thickness, anastomosing to form patches up to 8 mm. long, basidia borne at the tips of long branched hyphae with clamp connections, composed of a long stalk and a four-celled spore-producing part, measuring in all 5.1–7.2 × 97–268 μ (Bresadola: 4–6 × 75–200 μ), sterigmata variable in length, basidiospores mostly obovate, apiculate, 5.9–8.1 × 9.1–12 μ (Bresadola: 7–9 × 10–13 μ),



FIGS. 1-3 Georgia Tremellales.

germinating by repetition or budding out globose to subglobose conidia, 2.6–5.3 × 2.6–6.5 μ (Bresadola: 3.5–4 × 4–5 μ).

Growing from the perithecial stromata of *Botryosphaeria*, on a *Mimosa* branch lying on the ground, Athens, Georgia, December 19, 1945. Probably rare.

Bresadola reports that in his collection the fungus was growing on the bark of elm. Upon examining a portion of the type specimen, I found that it was growing over a sphaeriaceous fungus on the elm.

Occasionally the basidia germinate abnormally by producing conidia similar to those produced by the basidiospores. In the formation of a basidium, it is interesting to note that the lower part of the probasidium becomes very vacuolate and most of its protoplasmic contents pass into the upper part, after which a cross wall appears, cutting off the empty part (stalk cell) from the upper part which produces the spores. This stalk cell effect frequently is observed at the bases of some rust basidia, as in *Gymnosporangium*. It seems to function in bringing the spore-producing part of the basidium closer to the surface of the gelatinous medium in which it is embedded.

PLATYGLOEA UNISPORA Olive. Jour. Elisha Mitchell Sci. Soc. **60**: 17. 1944. (FIG. 2.)

With the exception of a few details the present collection, which represents the second record of the fungus, is very similar to the type specimen collected in North Carolina. The small waxy gelatinous fructifications are pulvinate or flattened-pulvinate, yellow, orange yellow, or cinnamon brown in color, measuring 0.3–1 mm. in diameter. Paraphyses are scattered among the basidia. As was pointed out in the original description the basidia are mostly one-celled. Although septa sometimes develop, they break down during the formation of the single large basidiospore. The basidiospores are oval to obovate, distinctly apiculate, and measure 10–14 × 14.3–20.2 μ. Not noticed in the original collection is the tendency of the basidiospores to become 2–4-celled. A cytological study of the basidia and spores of this fungus should prove to be of considerable interest.

Only one collection; growing on dead cedar branches lying on the ground, Athens, Georgia. January 18, 1946.

SIROBASIDIUM BREFELDIANUM Möller. Protobasidiomyceten. 1895. (FIG. 10.)

The species seems to have been reported only once previously in this country since its discovery by Möller in South America. Coker (**1920**) found a single specimen of it in North Carolina. One other species, *S. sanguineum* Lag. & Pat., has been collected in North Carolina by Coker (**1928**) and in Maryland by Olive (**1946a**). Both fungi are apparently rare in this country.

The fructifications of the Georgia collection appear as soft, white, gelatinous pustules, measuring 0.5–2 mm. in diameter. They dry to an invisible hyaline film. The fructifications are composed mainly of a few much-branched paraphyses and numerous chains of basidia, generally with clamp connections at their bases. The basidia are borne 3–10 in a chain and vary in shape from sub-globose to pyriform or racket-shaped. They are usually two-celled, sometimes three- or four-celled with oblique, vertical, or sometimes transverse septa, and measure 10.7–17.5 × 16 5–48.5 μ. The basidiospores are generally produced directly from the basidial cells and are therefore sessile, but sometimes they are produced on short cylindrical outgrowths, which, however, do not appear to be true sterigmata. The basidiospores vary from ovate or pyriform to narrowly elliptic, measure 7.4–12.6 × 15.5–28.1 μ, and frequently germinate to produce small oval conidia.

One collection; growing on corticate *Mimosa* limbs, Athens, Georgia. December 14, 1945.

TREMELLA MYCOPHAGA var. OBSCURA Olive. Mycologia **38**: 540. 1946.

This variety of *Tremella mycophaga* Martin seems to be fairly common in our area, always as a parasite of *Dacrymyces*, as it was in the type collection from North Carolina.

Parasitizing *Dacrymyces deliquescens* Duby, *D. minor* Peck, and *D.* sp., Athens, Georgia. Fall–spring, 1945–1946.

TREMELLA CARNEOALBA Coker. Jour. Elisha Mitchell Sci. Soc. **35**: 146. 1920.

There do not appear to be any very important differences between my collection and the material originally described by Coker. I have examined the latter and find that it resembles my collection in macroscopic appearance and hymenial structure. The Georgia collection has clamp connections, which were not reported by Coker, but this is of secondary importance.

The fructifications are rather soft, gelatinous, grayish hyaline to smoky white, some becoming very much corrugated and undulate, flattened, measuring 0.75–3 mm. in diameter, occurring in patches up to 3 cm. in length. Clamp connections are abundant. The basidia are globose to obovate, 2–4-celled, and measure 11.7–16.9 × 13.7–24.1 μ. They proliferate from beneath other basidia. Basidiospores are broadly obovate to globose and measure 6.5–9.1 × 6.6–11.7 μ. They germinate by repetition or bud out conidia in yeast-like fashion.

Growing on much decayed frondose wood, probably *Mimosa*, Athens, Georgia. October 28, 1945. Rare.

TREMELLA LUTESCENS (Pers.) Fries. Syst. Myc. 2: 213. 1822.

The fructifications are quite large and conspicuous, in our collection measuring up to 3 cm. in diameter and varying in color from apricot yellow to a light faded yellow. They are much folded and lobed. Some of the fructifications are entirely conidial, whereas others are both conidial and basidial. The conidia are yellow, spherical to oblong, and measure 1.8–4.2 × 2.6–5.9 μ. The basidiospores are subglobose to obovate and measure 8.5–10.4 × 11.7-15.6 μ.

Although in a recent publication (**1946a**), I was inclined to follow Martin (**1944**) in considering *T. mesenterica* and *T. lutescens* as distinct species, I do not feel now that this concept is correct. Martin prefers to reserve the name *T. mesenterica* for those forms which may produce both conidia and basidia. He also believes that there exist certain other microscopical differences. I have not observed them. Coker (**1920**), Looney (**1933**), and Bjørnekaer (**1944**) consider these fungi as two different phases of the same species. Bjørnekaer finds that the phase considered at *T. mesenterica* is the winter stage of *T. lutescens*, and that the latter name applies to the summer phase. My own observations show that measurements of basidia and basidiospores are too intergrading to afford a separation of the two phases into distinct species on this basis.

Collected on corticate frondose limbs, probably of tulip poplar, and on decorticate pine wood, Athens, Georgia. April, 1946.

TREMELLA FOLIACEA (S. F. Gray) Pers. Myc. Eur. p. 101. 1822.

A rather large fructification, 5.5 × 8 cm., and several smaller ones were collected in a single locality. The color is a dark cinnamon brown when moist, blackish when dry. The fructifications are composed of many thin, crowded, undulate lobes. There is not a great deal of shrinkage on drying. The basidiospores measure 6.8–9.1 × 8.2–10.1 μ.

Growing on an old uprooted oak stump, Athens, Georgia. September–December, 1945. Uncommon.

EXIDIA SPICULOSA (S. F. Gray) Somm. Supp. Fl. Lapp. **307**, 1826.

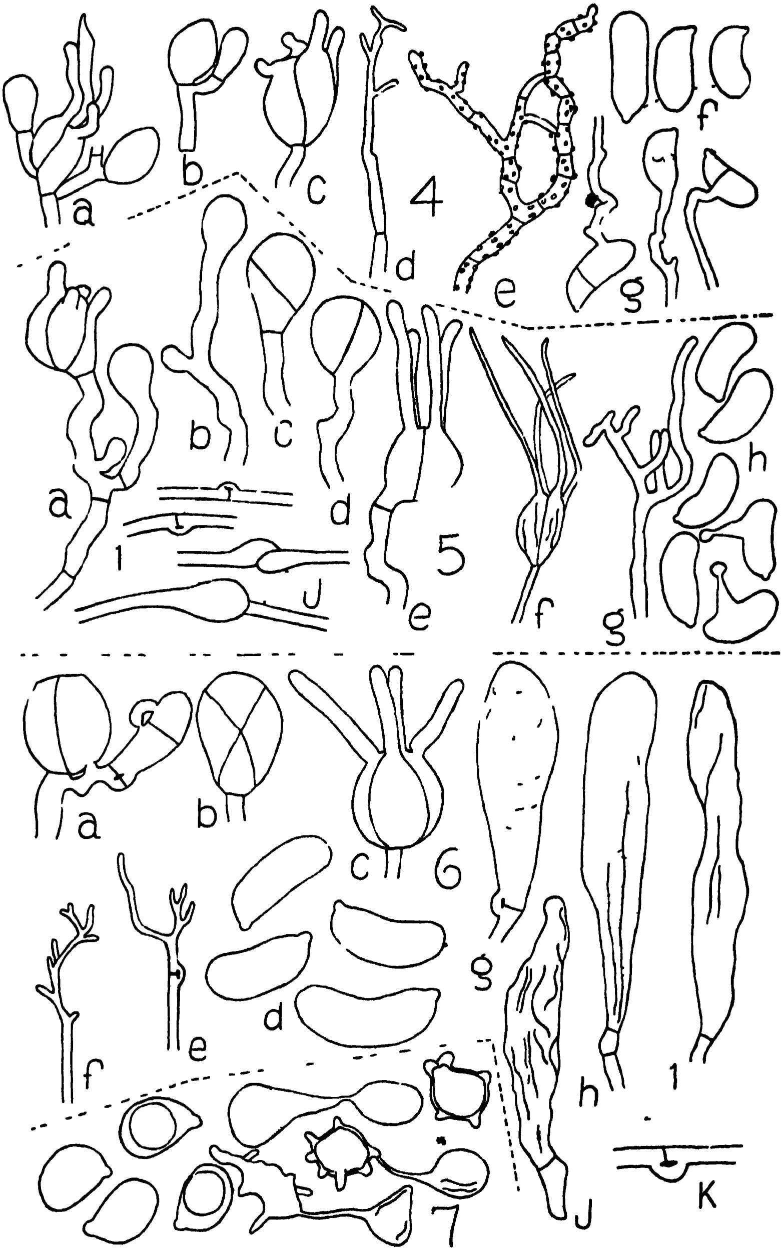
This species is one of our most common jelly fungi. It was found abundantly from fall to spring on fallen branches of frondose trees.

EXIDIA RECISA (S. F. Gray) Fries. Syst. Myc. **2**: 223. 1822.

A very common species in our area, occurring on frondose wood and often attacking dead limbs still on the tree. Found at all times of the year. This and the preceding species seem to be the two most common jelly fungi in our area. Both are probably active lignivores.

EXIDIA SPICULATA Schw. Amer. Phil. Soc. Trans. N.S. **4**: 185. 1832. (FIG. 5.)

Schweinitz discovered the fungus in Pennsylvania, and Burt (1921) found it later in Vermont and New York. These are the



FIGS 4–7. Georgia Tremellales.

only previous records of the species that I have found. I have examined Burt's Vermont collection and find it very similar to our collection in macroscopic appearance.

Since the plant has seldom been collected and is little known, a description of our collection is included here.

Fructifications 0.5–4 cm. in diameter, 3.7 mm. high; pulvinate to expanded and gyrose, the larger fructifications much crumpled and contorted with undulate lobes; chestnut brown to argus brown; sessile, attached centrally or along one edge; upper and lower surfaces smooth, non-glandular, containing numerous small, white calcareous granules somewhat similar to those of *E. nucleata;* drying to a dark brown rugose layer with calcareous granules frequently visible.

Hyphae with numerous clamp connections, often enlarging at the septa. Branched paraphyses present. Basidia subglobose to oval, mostly four-celled, septa vertical or more often oblique, basal septa formed tardily and without clamp connections; basidia measuring 9.3–10.7 × 10.4–15 μ; basidiospores somewhat reniform, 3.9–5.2 × 10.4–13.5 μ, germinating by repetition or sometimes producing small, rod-shaped conidia. Burt gives the basidial measurements as 6 × 9 μ and spore measurement as 4 × 9–10 μ.

Collected on old oak log, Athens, Georgia. December 19, 1945. Rare.

EXIDIA COKERI Olive. Jour. Elisha Mitchell Sci. Soc. **60**: 18. 1944. (FIG. 4.)

This appears to be the second finding of the fungus since its discovery in North Carolina. The Georgia collection is characterized by small, brownish, pustulate fructifications, 100–400 μ in diameter.

The material reported here differs little from the original description of the species. Numerous branched paraphyses, generally roughened with brownish granules, are abundant. The globose to pyriform basidia measure 9.1–11.6 × 9.8–15 μ. The basidiospores are reniform to almost straight cylindrical, apiculate, 4.6–5.2 × 10.4–16.3 μ. They become septate and germinate only by the production of irregular germ tubes in this specimen.

Some of the spores of the type collection were described as becoming 1–4-septate. Later, considering the possibility that some spores of *Dacrymyces* had become mixed in with those of the *Exidia*, I reëxamined the type collections. No evidence of this was found, however. It is certain that the basidiospores of the Georgia collection almost exclusively become uniseptate and produce irregular germ tubes.

Collected on bark of hickory limb, Athens, Georgia, September 29, 1945, and at Whitehall, near Athens, December 15, 1945. Apparently uncommon, or overlooked because of its inconspicuous fructifications.

EXIDIA NUCLEATA (Schw.) Burt. Ann. Mo. Bot. Gard. **8**: 371. 1921.

This fungus is easily recognized in the field by the hyaline, pinkish, or vinaceous color of its pulvinate or crumpled fructifications and by the presence of numerous white calcareous granules.

Collected on corticate frondose wood, Athens, Georgia. Winter, 1945–46. Not uncommon.

Seismosarca tomentosa sp. nov. (FIG. 6.)

Hyalina vel alba aut fumaginea, interdum dilutissime rosea, primitus albatomentosa, demum levigata, erumpens, pulvinata, plerumque cerebriformis, 1–2 mm. alta, 2–8 mm. lata; fructificationibus interdum confluentibus, intus cartilagineis, extus gelatinosis, siccis flavis usque atris, aliquantulum collapsentibus, marginibus albido-tomentosis. Paraphysibus numerosis, parum vel multum ramosis, 0.7–2 μ crassis; gloeocystidiis elongatis, clavatis, hyalinis, collabentibus, 7.8–13.6 × 24.3–74.7 μ; basidiis subglobosis vel obovatis, 11.7–13.7 × 13.7–19.5 μ, sterigmatis 42–131 μ longis; basidiosporis cylindratis, leviter curvatis, apiculatis, 5.8–7.0 × 16.2–21.1 μ.

Fructifications dull white, hyaline, pinkish, or smoky, white tomentose when young, becoming smooth at maturity, surface sometimes dotted with a few scattered black tubercles; center of fructifications cartilaginous-gelatinous, outer part gelatinous, pulvinate, generally cerebriform, 1–2 mm. thick, 2–8 mm. in diameter, erumpent, sometimes anastomosing; drying to horny, yellowish to black pulvinate masses or membranes, usually with a conspicuous white tomentose border.

Clamp connections abundant; paraphyses abundant, little to much branched, somewhat tortuous, extending beyond the basidia, measuring 0.7–2 μ in diameter, gelatinizing, and becoming indistinct. Gloeocystidia numerous, mostly elongate clavate, contents hyaline or sometimes becoming yellowish, collapsing soon after maturity, measuring 7.8–13.6 × 24.3–74.7 μ. Basidia subglobose to obovate, mostly four-celled, septa vertical or more rarely oblique, 11.7–13.7 × 13.7–19.5 μ, sterigmata 42–131 μ in length. Basidiospores cylindrical and slightly curved, apiculate, 5.8–7.0 × 16.2–21.1 μ.

Growing on fallen corticate limbs of frondose tree; two collections, Athens, Georgia. November 15 and 22, 1945. Rare.

Two other species of *Seismosarca,* namely *S. hydrophora* Cooke and *S. alba* Lloyd, have been reported in the United States. The new fungus, however, is decidedly unlike these in general appearance and in microscopic details. The tomentose character of its young fructifications and the presence of a whitish border around the dried fruiting bodies make it a fairly distinct species in the field. The whitish border appears to be a kind of subiculum.

SEBACINA EPIGAEA (Berk. & Br.) Bourd. & Galz. Hymén. Fr. p. 39. 1928. (FIG. 7.)

I have found this to be an abundant, but extremely variable species. In my collections the fructifications vary from small separate pustules to a conspicuous and continuous layer, white, gray, or brownish yellow in color, gelatinous in texture, often revealing an arachnoid to corticioid yellowish subiculum on drying, or subiculum absent. The basidia in the Georgia collections measure 8.8–15.5 × 11.7–21.5 μ; the basidiospores, 5.2–8.9 × 7.8–13.8 μ. The most constant character that I have found as an aid to identification is the tendency of the spores to become transformed into irregular thick walled cells, covered with papillae.

Collected on old frondose wood (*Mimosa,* oak, birch, silverberry) and on branches of red cedar, Athens, Georgia. Common throughout the fall and winter.

SEBACINA MOLYBDEA McGuire. Lloydia **4**: 17. 1941.

The species was discovered in Iowa and has since been reported only in North Carolina (**1944**). My collections of it in Georgia differ from previously described specimens mainly in the absence of clamp connections. The basidia tend to be slightly longer.

Two collections on fallen branches, one growing profusely along corticate branches of wild cherry, and the other on corticate and decorticate parts of an old persimmon branch, Athens, Georgia. November, 1945.

SEBACINA PLUMBESCENS Burt. Ann. Missouri Bot. Gard. **3**: 241. 1916.

The fructifications tend to be thicker (320–680 μ) than indicated by McGuire (**1941**) in his monograph of the group. A few small calcareous granules are present. The basidia measure 9.8–12.4 × 11.7–13.7 μ and the basidiospores, 4.9–6.3 × 10.4–15.6 μ. These measurements are slightly smaller than those given by McGuire. Otherwise, the fungus agrees rather well with the latter's description.

Only one collection; growing on bark of fallen tulip poplar branch, Athens, Georgia. April 17, 1946.

SEBACINA PODLACHICA Bres. Ann. Myc. **1**: 117. 1903.

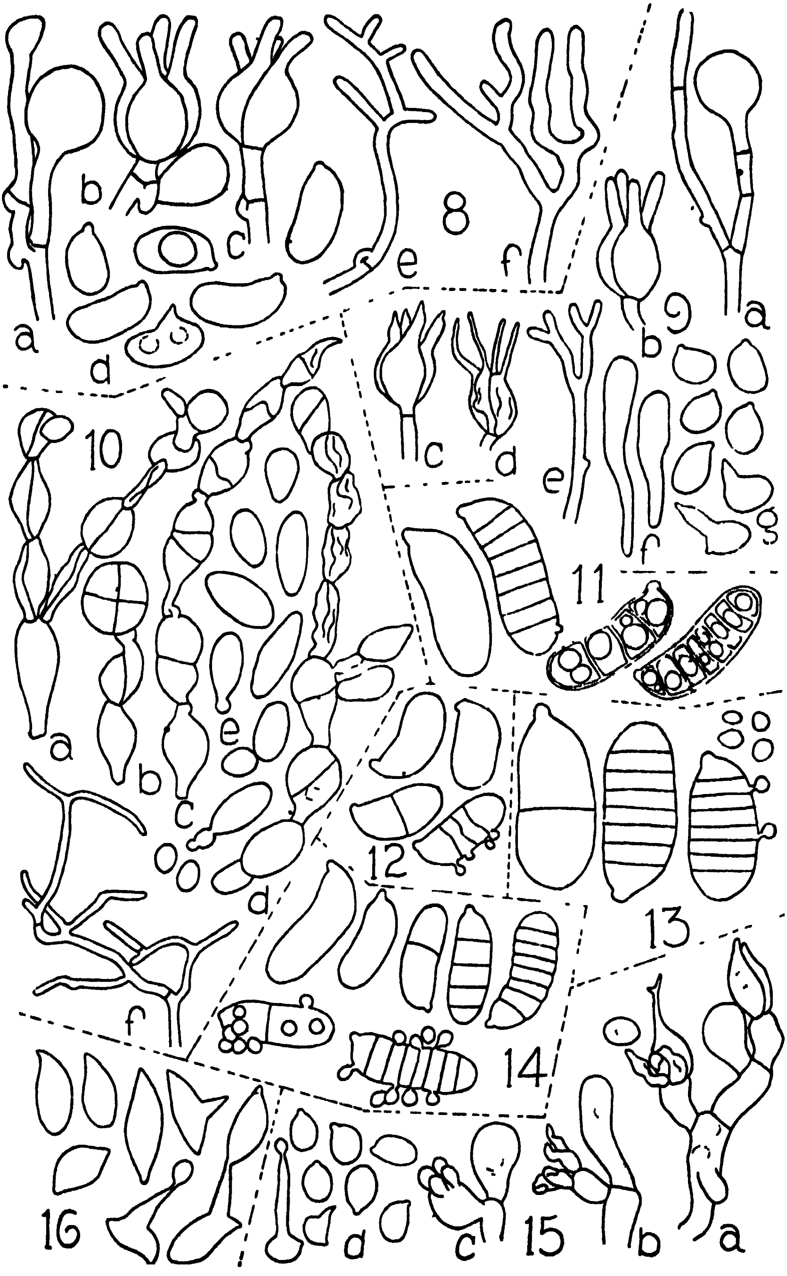
The fungus agrees quite well with McGuire's description of it. It is notably a rather variable species. My specimens show considerable variability in thickness, texture, and color of fructifications, in the presence or absence of calcareous nodules, and in the presence or absence of cystidia and clamp connections.

Growing on fallen corticate branches of oak, elm, silverberry, and wild cherry, Athens, Georgia. October–December, 1945. Fairly common.

SEBACINA SUBLILACINA Martin. Mycologia **26**: 262. 1934.

The fungus is readily recognizable from the standpoint of its thin, slate gray, waxy-gelatinous fructifications, with small, thin-walled, subulate cystidia as seen under the microscope. Calcareous granules were present in one of my collections and absent in the other.

Growing on very rotten corticate limb of tulip tree and on a thelephoraceous fungus on the underside of a corticate birch limb, Athens, Georgia. November, 1945. Apparently uncommon.



FIGS. 8–16. Georgia Tremellales.

DICELLOMYCES GLOEOSPORUS Olive. Mycologia 37: 543–552. 1945.

I have not yet had the opportunity of obtaining further collections of the fungus since its original description. Considering the fact that one of the type specimens was collected at Savannah, I am including it here. The fungus is a parasite on *Arundinaria* leaves. In spite of its parasitic nature, it has many important characters which would seem to place it among the Dacrymycetaceae.

I am grateful to Dr. G. W. Martin for examining the type collections and bringing to my attention a feature which I overlooked in writing the original description. The hymenium contains, in addition to probasidia and basidia, numerous very slender, unbranched paraphyses with knob-like swellings at the tips. These paraphyses apparently become gelatinized in older fructifications.

DACRYMYCES ABIETINUS (Pers.) Schroet. Krypt. Fl. Schles. 3: 400. 1888. (FIG. 11.)

The fructifications of this plant are quite small in my collection (0.5–1.6 mm. in diameter) and the spores measure 7.2–8.5 × (15–)18.2–24.7 μ. It is a distinct and easily identified species.

Growing on decorticate pine limbs, Athens, Georgia. April 17, 1946. Uncommon.

DACRYMYCES MINOR Peck. Ann. Rep. N. Y. State Mus. 30: 49. 1877.

I have experienced considerable difficulty in identifying and separating specimens of *D. minor*, *D. deliquescens*, and at times *D. Ellisii*. The three species often have many characters that intergrade. These include color, size, and shape of fructifications, presence or absence of clamp connections, spore size, gelatinization of spore septa, and others. I have designated a number of specimens as *Dacrymyces minor* Peck mainly on the basis of their tendency to produce smaller, narrower basidiospores. These become 1–3-septate and measure 3.3–5.9 × 9.1–13.7 μ. The septa sometimes gelatinize as in *D. deliquescens*. No clamp connections were observed on the hyphae. The reader is referred to the monograph of Brasfield (1938) for a more detailed description of the species of *Dacrymyces* listed in this paper.

Collected throughout the fall, winter, and early spring, 1945–46, on corticate and decorticate branches of frondose trees and once on decorticate pine, Athens, Georgia. Common.

DACRYMYCES DELIQUESCENS Duby. Bot. Gall. p. 729. 1829.

In my collections the fructifications measure 0.5–5 mm. in diameter. The species may generally be distinguished from *D. minor* by the presence of somewhat larger basidiospores, but even here there is some intergradation. In our collections the spores become mostly triseptate and measure 4.7–7.8 × 12.8–19 μ. The septa and walls of the basidiospores frequently become gelatinized and thickened. Clamp connections may be present or absent.

Growing on both coniferous and frondose wood, Athens, Georgia. Fall and winter, 1945–46. Common.

DACRYMYCES ELLISII Coker. Jour. Elisha Mitchell Sci. Soc. **35**: 167. 1920.

Generally, this species of *Dacrymyces* may be distinguished from *D. minor* and *D. deliquescens* in that its fructifications average somewhat larger (2–13 mm. in diameter in ours) and are usually attached by white radicating bases. The basidiospores become triseptate and measure 4.3–7.8 × (10.4–)12–17.6 μ. The septa and spore walls apparently do not gelatinize. Clamp connections may be present or absent.

Growing on corticate and decorticate frondose wood, especially oak, Athens, Georgia. Winter and spring, 1945–46. Common.

GUEPINIA ELEGANS Berk. & Curt. Jour. Bot. & Kew. Misc. 1: 239. 1849. (FIG. 12.)

Our specimens differ in few details from the description given by Brasfield. The fructifications are on the average considerably smaller, not exceeding 5.5 mm. in diameter and measuring 2–6 mm. in height. The spores become 1–3-septate and measure 5.9–7.2(7.8) × 13.0–16.9(18.2) μ. These measurements are somewhat greater than those given by Brasfield.

One collection, growing on very rotten, decorticate frondose wood, Athens, Georgia. December 11, 1945. Rare.

GUEPINIA SPATHULARIA (Schw.) Fr. Elench. Fung. **2**: 32. 1828.

The easily recognized bright orange, spathulate fructifications of this plant were found in lines along old stems of crêpe myrtle, Athens, Georgia. October 23, 1945. Apparently uncommon.

CALOCERA CORNEA Fries. Syst. Myc. **1**: 485. 1821.

Collected twice on rotten frondose wood, Athens, Georgia. October 5, 1945. Not very common.

DACRYOMITRA NUDA (Berk. & Br.) Pat. Essai Tax. p. 31. 1900.

Collected once on corticate pine branches, Athens, Georgia. April 10, 1946. Rare.

GUEPINIOPSIS CHRYSOCOMUS (Bull.) Brasfield. Amer. Midl. Nat. **20**: 226. 1938. (FIG. 13.)

The pezizaeform to expanded fructifications of our collections vary in color from chamois yellow to brown and russet. They are firmly gelatinous and measure 2–7 mm. in diameter. The basidiospores become 7-septate and are quite large, 8.7–12.4 × 17.5–30 μ. Coker's description (**1920**) of *Dacrymyces pedunculatus* (B. & C.) Coker, a synonym of the above, fits our specimens somewhat better than the description given by Brasfield (**1938**).

Collected on corticate pine branches, Athens, Georgia. January–April, 1946. Fairly common.

FEMSJONIA PEZIZAEFORMIS (Lev.) Karst. Mycol. Fenn. **3**: 353. 1876. (FIG. 14.)

This probably represents the first report of the species in the South. Martin says that it is widespread in the cooler parts of the northern hemisphere and gives Ontario and Ohio as the localities for his collections. A description of our specimens follows:

Fructifications erumpent, disc-shaped to pezizaeform, sometimes in the form of irregular pulvinate masses, surface frequently undulate or folded, with radicating bases passing through the bark. The fructifications are firmly gelatinous, mostly cadmium to aniline yellow, measure 2–8 mm. in diameter, shrink on drying to orange brown or reddish brown masses, and frequently withdraw into the bark. A smooth hymenium lines the concave part of the fructification, whereas the outside is covered with a whitish tomentum. Clamp connections abundant and conspicuous at all septa. Basidia yellowish; basidiospores measuring 5.2–7.8 × 13–26 μ, becoming 1–8-septate and producing small globose conidia.

Two collections on old corticate branches of tulip poplar, Athens, Georgia. November 29, 1945. Rare.

TULASNELLA VIOLEA (Quél.) Bourd. & Galz. Bull. Soc. Myc. Fr. 25: 31. 1909. (FIG. 15.)

The species has a wide distribution, having been reported in Europe, the northern United States, and tropical America. This seems to be the first record of it in the southeastern states.

In our single collection, the fungus is broadly effuse, thin but conspicuous, pruinose, not at all gelatinous, pale lilac when moist, drying pale lilac to lilac gray. The hyphae are rather broad, abundantly septate, and devoid of clamp connections. The basidia are typical, usually with four fusiform epibasidia, and the basidiospores are obovate, usually slightly flattened on one side, obliquely apiculate, measure 3.6–4.6 × 5.3–8.1 μ, and germinate by repetition.

Growing on bark of frondose limb, Athens, Georgia. April 16, 1946. Apparently rare in our area.

TULASNELLA VIOLACEA (Johan-Olsen) Juel. Bih. Svensk. Vet.-Akad. Handl. 23: 22. 1897. (FIG. 16.)

This is the second report of the species in the southern states. It was recently collected by me in North Carolina (1946).

The fungus fits well into the description given by Rogers (1933) in his monograph of the group. It is rather easily recognized from the standpoint of its general appearance and its peculiarly shaped basidiospores (see FIG. 16). The basidiospores measure 3.9–5.5 × 9.8–16.3 μ and germinate by repetition.

Growing on underside of an old oak limb, Athens, Georgia. January 18, 1946. Collected only once.

GLOEOTULASNELLA PINICOLA (Bres.) Rogers. Ann. Mycologici 31: 199. 1933.

This appears to be the most abundant member of the Tulasnellaceae in our area. It is an extremely variable species in many ways. Our collections are soft gelatinous or mucous-gelatinous, gray to brown, rather thin, and with an undulate or bumpy surface. The basidia are typical, arising from erect hyphae of rather large diameter. This latter character is one of the most constant and helpful ones in identification. The basidiospores vary from subglobose to subcylindric and measure 3.9–5.2 × 5.9–9.1 μ.

Collected on corticate and decorticate frondose wood (oak, tulip poplar, river birch, hickory, and *Mimosa*). Common from fall to spring, 1945–1946, Athens, Georgia.

DEPT. OF BOTANY, BACTERIOLOGY AND PLANT PATHOLOGY,
LOUISIANA STATE UNIVERSITY,
BATON ROUGE, LA.

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EXPLANATION OF FIGURES

(All figures × 880, unless otherwise indicated.)

FIG. 1. *Platygloea Miedzyrzecensis.* *a*, section of fructification on perithecial stroma of *Botryosphaeria* (× 46); *b–g*, development and sporulation of the basidia (× 600); *h*, basidiospores, some germinating by repetition; *i*, basidium producing conidia; *j*, basidiospores producing conidia; *k*, conidia. FIG. 2. *Platygloea unispora.* *a*, group of basidia; *b*, basidiospores; *c*, basidium and paraphysis-like structure; *d*, basidium sporulating; *e*, paraphysis. FIG. 3. *Platygloea peniophorae.* *a*, basidiospores; *b*, group of basidia and conidiophores; *c*, conidia; *d*, *e*, conidiophores, showing development of clamp connections at apex; *f*, *g*, hyphae with clamp connections and haustorial branches. FIG. 4. *Exidia Cokeri.* *a–c*, probasidia and basidia; *d*, *e*, paraphyses; *f*, basidiospores; *g*, basidiospores (two of them septate) germinating. FIG. 5. *Exidia spiculata.* *a–f*, development of the basidia; *g*, paraphysis; *h*, basidiospores, some germinating by repetition; *i*, hyphae with clamp connections; *j*, hyphae swollen at the septa. FIG. 6. *Seismosarca tomentosa.* *a–c*, development of the basidia; *d*, basidiospores; *e*, *f*, paraphyses; *g–j*, gloeocystidia; *k*, hypha with clamp connection. FIG. 7. *Sebacina epigaea.* Basidiospores, some germinating by repetition, some becoming irregular and papillate. FIG. 8. *Sebacina plumbescens.* *a–c*, development of the basidia; *d*, basidiospores; *e*, *f*, paraphyses. FIG. 9. *Sebacina podlachica.* *a–d*, development of the basidia; *e*, paraphysis; *f*, cystidia; *g*, basidiospores, some germinating by repetition. FIG. 10. *Sirobasidium Brefeldianum.* *a–d*, chains of basidia in various stages of development; *e*, basidiospores, some budding out conidia; *f*, paraphysis. FIG. 11. *Dacrymyces abietinus.* Basidiospores. FIG. 12. *Guepinia elegans.* Basidiospores, one producing conidia. FIG. 13. *Guepiniopsis chrysocomus.* Basidiospores, one producing conidia. FIG. 14. *Femsjonia pezizaeformis.* Basidiospores, two producing conidia. FIG. 15. *Tulasnella violea.* *a–c*, development of the basidia; *d*, basidiospores, some germinating by repetition. FIG. 16. *Tulasnella violacea.* Basidiospores, some germinating by repetition.

THE FEULGEN REACTION AS A CYTOLOGICAL TECHNIQUE WITH ALLOMYCES ARBUSCULA

RICHARD C. JONES

THE FEULGEN REACTION: A modified Feulgen technique has been used successfully in staining nuclei of *Allomyces arbuscula.* Experiments have been run for the purpose of determining optimum conditions for fixation, hydrolysis, staining, and bleaching.

TYPE OF FIXATIVE: Four fixatives were tested: Feulgen's, Carnoy's A, Carnoy's B, and a Meve's modification of Flemming's solution. Young plants of *Allomyces* were fixed in each of these four solutions for periods varying from ten minutes to seventy-two hours, and subsequently stained and examined for the quality of fixation. More importance was attached to the proper fixation of nuclei than to fixation of the cytoplasm.

LENGTH OF FIXATION: Young plants of *Allomyces arbuscula* were fixed for periods of 10, 15, 20, and 30 minutes and for 1, 2, 3, 5, 9, 12, 18, 24, 36, 48, and 72 hours in each of the four fixatives. The results showed a maximum fixation attained with a different period for each reagent. Plants fixed in Feulgen's solution showed progressively better results up to about forty-eight hours, after which no noticeable difference could be detected. Material fixed with Carnoy's A appeared to attain a maximum fixation between three and five hours, and here too there was no apparent improvement or deterioration from this point. The optimum period of fixation with Carnoy's B was about two hours, and material which was fixed for more than three hours in the reagent showed signs of overfixation; artifacts were increasingly more frequent in material fixed from three to seventy-two hours. The plants fixed in Flemming's solution (Meve's modification) were, to all appearances, fixed as well in five hours as they were after a longer period, and several hours of fixation beyond this point seemed not to affect the results appreciably.

TYPE OF FIXATION: Material fixed in Feulgen's and Carnoy's B showed in general very satisfactory results. Fixation by Carnoy's A seemed to distort the nuclei causing them to appear abnormally elongate. Meve's modification of Flemming's solution gave generally the poorest results of the four fixatives, the cytoplasm appearing so heavily granular as to interfere with study of the nuclei.

HYDROLYSIS: Satisfactory hydrolysis was obtained with 1.0 normal. When the material is removed from the hydrolyzing agent 0.5 normal hydrochloric acid for 18 to 20 minutes at 58° C. Injury to the hyphae may result if the temperature is allowed to exceed 60° C. or if the concentration of acid is greater than 1.0 normal. When the material is removed from the hydrolyzing agent some shrinkage of cytoplasm can be avoided by dipping the material into cold (room temperature) 1.0 normal hydrochloric acid before placing it in the distilled water rinse prior to staining.

STAIN: Staining solutions were prepared from seven different lots of basic fuchsin. Four of these lots were several years old (their age being figured from their date of purchase); the other three lots were all acquired directly from chemical supply companies. All of the fresh lots gave satisfactory results, but the older lots proved less reliable, two of them being unsatisfactory. However, the oldest lot of all, a fuchsin purchased thirty years ago, gave the most satisfactory reactions.

The effect of the Coleman technique for decolorization was tested for each stain, and although it resulted in complete decolorization in every case, and noticeably improved the staining qualities of the poorest fuchsins, the solutions which gave good stains without it showed no marked improvement as a result of the further decolorization. As a matter of fact, some of the best slides prepared were stained with a clear amber-colored staining solution.

STAINING PERIOD: Vigorous young plants of *Allomyces arbuscula* were stained for periods of 1, 1½, 2, 3, 5, 15, 20, and 30 minutes and for 2, 3, 5, 7, 15, 17, and 24 hours. There seemed to be no danger of overstaining with any of these periods. The intensity of the stain increased visibly up to the five-hour period, and the ability of the nuclei to retain the stain increased up to the ten-hour period. In general it may be said that a long stain of five hours to overnight gave the best results.

BLEACH: The bleaching solution employed in these studies was the sulphur dioxide in water bleach recommended by Johansen (1). Stained plants were bleached for 30 seconds, and for 1, 2, 3, 5, 8, 10, 15, 20, and 30 minutes. For a five-hour stain, it was observed that a quick dip-bleach was sufficient to clear the hyphae, the material being dipped into three successive dishes of the bleaching solution. In no case, even with the twenty-four hour stain, was a bleaching period of greater than five minutes required for satisfactory results.

DEHYDRATION AND MOUNTING: The plants were transferred from the bleach to a distilled water rinse for from ten minutes to overnight, and dehydrated through the following alcohol and xylol series: alcohol 20%, 30%, 50%, 75%, 85%, 95%, 100%, 75% alcohol and 25% xylol, 50% alcohol and 50% xylol, 25% alcohol and 75% xylol, and 100% xylol. The plants were left for at least five minutes in each of these solutions and for ten minutes in the 85%, 95%, and 100% alcohols. The material was then mounted in Canada balsam.

MECHANICAL TECHNIQUE: The numerous transfers of these delicate plants from one to another solution presented a problem in mechanical injury to the hyphae. This problem, however, was solved by the use of a simple instrument, fashioned by fusing the edge of a glass cover-slip to the end of a glass rod in the flame of a bunsen burner. When the angle subtended by the cover-slip was about 115 degrees and the glass rod was held as one would hold a pencil, the cover-slip provided a flat surface onto which the mycelial tuft could be floated by simply bringing the cover-slip up underneath the floating plant. The transfer was then accomplished by floating the plant off into the next solution in the series. In this work, the transfers were made into Stender culture dishes which contained the reagents.

SUMMARY OF STAINING TECHNIQUE:

Feulgen fixation for 48 hours or Carnoy's B for 2 hours.
Rinse in distilled water for 20–30 minutes.
Cold (room temperature) 1.0 normal hydrochloric acid for 5 minutes.
Hot (58° C.) 1.0 normal hydrochloric acid for 5–7 minutes.
Cold (room temperature) 1.0 normal hydrochloric acid for 5 minutes.
Rinse in distilled water for 5 minutes.
Stain in fuchsin sulphurous acid 5–10 hours (or up to 24 hours without danger of overstaining).

Bleach in water containing sulphur dioxide 30 seconds to 5 minutes.
Rinse well in distilled water.
Dehydrate and clear:

5 minutes each in 20%, 30%, 50%, 70% alcohols
10 minutes each in 85%, 95%, 100% alcohols
5 minutes each in 75% alcohol and 25% xylol, 50% alcohol and 50% xylol, 25% alcohol and 75% xylol, and 100% xylol.

Mount in Canada balsam or clarite.

FORMULAE

Fixing Fluids

1. Feulgen's fixative		
Corrosive sublimate (6% aqueous solution)	98	parts
Glacial acetic acid	2	parts
2. Carnoy's fluid (A)		
100% Ethyl alcohol	15	cc.
Glacial acetic acid	5	cc.
3. Carnoy's fluid (B)		
100% Ethyl alcohol	30	cc.
Glacial acetic acid	5	cc.
Chloroform	15	cc.
4. Flemming's solution (Meve's modification)		
0.5% Chromic acid	15	parts
Glacial acetic acid	1	part
2% Osmic acid	2	parts

Staining Solution

Basic fuchsin	5	grams
Distilled water	100	cc.
1/N Hydrochloric acid	10	cc.
Potassium metabisulphite	0.5	gram

Dissolve the basic fuchsin by pouring over it the boiling distilled water and shaking thoroughly. Cool to 50° C. and filter. To filtrate add the hydrochloric acid; cool to 25° C. and add potassium metabisulphite. Shake well, stopper tightly, and place in darkness for 18–24 hours.

Bleaching Solution

1.0 Normal hydrochloric acid	5	cc.
10% Aqueous potassium metabisulphite	5	cc.
Distilled water	100	cc.

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DEPARTMENT OF BOTANY,
UNIVERSITY OF NEW HAMPSHIRE,
DURHAM, NEW HAMPSHIRE

PHOTOGRAPHS AND DESCRIPTIONS OF CUP-FUNGI—XLIII. SEAVERINIA

Fred J. Seaver

(with 1 figure)

The species on which the above named genus was founded was first observed by the writer about 1912 in the vicinity of The New York Botanical Garden. It has been observed and collected practically every spring since that time to the present, 1946. The only years in which it was not collected were those in which no effort was made to find it. It occurs from the latter part of April until around the first of June. No collections have been made in June. The fungus is outstanding since it was the first species in which a definite connection was made between a *Botrytis* and a *Sclerotinia.*

HISTORY OF THE FUNGUS

On May 23, 1917, the writer addressed a letter to H. H. Whetzel as follows: "For several years past I have been collecting each spring a *Sclerotinia* on the rootstocks of wild geranium. Perhaps you recall that I referred to this species when you were here. During the present spring I have found it as usual and have been following it up in the field with a hope of finding its conidial stage. I have been unable to find anything which appeared to be its conidial stage on the leaves of the same host. However, I have in culture a number of rootstocks which were infected with apothecia and in about a week I had the most beautiful growth of a *Botrytis.* I am sending a small specimen of this to you for examination. While the occurrence of *Botrytis* might be purely coincidence, it occurs with such great abundance in connection with the apothecia and rootstocks that I am inclined to suspect that there might be some connection between the two. If you can give me any light on the *Botrytis* as to its identity, the favor will be very greatly appreciated."

On May 29, 1917, Whetzel wrote in answer to the above: "I very much doubt that the *Botrytis* can be a conidial stage of your fungus on the wild geranium. Nevertheless this is quite possible, and I shall see what I can make out of it. However, I could come a great deal nearer answering the question if you could get me apothecia of the same fungus from which I could make ascospore cultures. The probability is that cultures from the *Botrytis* will give only *Botrytis*."

In the meantime, W. T. Horne who was doing culture work in the New York Botanical Garden kindly offered to test the *Sclerotinia* spores from which *Botrytis* was obtained in a very few days. On June 26, 1917, the writer wrote Whetzel as follows: "Since writing you we have cultured out the *Sclerotinia* on wild geranium and proved beyond the question of a doubt that the *Botrytis* is the conidial stage of this fungus. Professor Horne is here for a time and being interested he offered to culture the fungus. Excellent growth of conidia can be produced from the ascospores in four or five days. I thought you might be interested in knowing our results. We will publish a short paper in the near future. I would be glad to send you some of the perfect stage of the fungus but the last time I was out I could find none. It lasts only about a month in the spring. Unless we can decide on the specific name of the *Botrytis* we will call the fungus *Sclerotinia Geranii*. According to our rules the specific name of the *Botrytis* provided it has one, would be tenable for the species." This refers to the American rules which were being followed by us at that time. A brief note was published by W. T. Horne and the writer in *Science* (**46**: 163. 1917).

On July 2, Whetzel wrote: "I am delighted to have your letter of June 26. I want to congratulate you upon having made the connection between a *Botrytis* and the *Sclerotinia*. So far as I am aware this is the first authentic case of the connecting up of the *Botrytis* with the *Sclerotinia*, and it will be a very important contribution to the general subject." However, Whetzel was not inclined to accept our report at face value and since the fungus at that time was not known to occur in any other locality he planned to come to New York and study the fungus from fresh material.

On March 24, 1919, Whetzel wrote "I am planning definitely to come to New York this spring when that *Botrytis Sclerotinia* fungus is fruiting on the rootstocks of the wild geranium. I want to collect some material and make some isolations directly from the fresh stalk. I shall probably want to spend two or three days down there at the gardens working on the thing, will bring along the necessary media for making my isolations. I shall appreciate it if you will let me know as soon as you can just when will be the best time to collect the thing. If you find it appearing, you can telegraph me and I will get down within the next few days. I have a lot of interesting things in connection with *Sclerotinia* and *Botrytis* to talk over with you. We have made some new finds recently that will, I am sure, be of great interest to you."

On April 15, 1919, the writer wrote the following: "Dear Professor Whetzel: I was out through the woods yesterday and found a single cluster of *Sclerotinia* on wild geranium. This would indicate that it is rather early otherwise the fungus would appear in abundance. However, in accordance with your request, I am notifying you as a sort of preliminary report. I should say probably about the first of May it ought to be in good condition."

Accordingly Professor Whetzel was in New York on May 1, 1919, accompanied by Miss Cynthia Wescott who was acting as his assistant at the time. His work substantiated our results in every way.

DISTRIBUTION OF THE FUNGUS

Although this fungus was collected in New York as early as around 1912 and practically every season since in, usually, rather large quantity it had not been observed in any other locality until 1931 when Dr. J. J. Davis sent a small quantity collected by him in Wisconsin.

On May 8, 1932, Whetzel wrote "We were collecting at McLean's last Friday. You will be interested to know that one of the boys discovered a large area in which *Sclerotinia Geranii* was very abundant. It is the first time it has ever been found in the Cayuga flora so far as I know. It is certainly the first time I ever collected it. My memory is that you told me there are only two stations heretofore known for it in the United States, Van

Cortlandt Park and somewhere in Wisconsin. I believe you told me that Dr. Davis had sent you a specimen from Wisconsin. I should appreciate it if you would give me complete information as to where it has been found. I am sending you enclosed a specimen from McLean for your collection."

At the present time after more than thirty years since its discovery this fungus is still known from only three places in the world. It seems especially strange that this cup-fungus which is fairly conspicuous could have been overlooked in the Ithaca section for twenty years with Durand, Whetzel and their students scouring that region for Discomycetes. This leads the writer to suspect that it is a recent introduction, at least in the Ithaca region.

CHARACTERS OF THE GENUS

The *Botrytis,* which represents the conidial stage of the only species known in this genus at the present time, has tuberculate spores whereas all the other species of *Botrytis* known to Whetzel and to us at the time have smooth spores. This together with the absence of a true stroma in the rootstocks of the host led Whetzel to set it apart as a distinct genus. It is not the intention of the writer to discuss the merits of the genus but merely to present the facts and leave the reader to judge for himself. Since this is a monotypic genus, the characters of the species are those of the genus. For a detailed description of the genus see *Mycologia* (37: 705). There we find the following statement: "Conidial stage placed originally in the form-genus *Botrytis* by Seaver and Horne but excluded from it by Whetzel because the conidia differ from those of *Botrytis* of the *cinerea* type in being tuberculate." The writer does not agree that the conidial stage should be excluded from the form-genus *Botrytis* because of its rough spores unless a new form-genus be established, for there is no other known form-genus in which it can be placed. The following name is therefore proposed for the conidial stage of the fungus:

Botrytis Geranii sp. nov.

Conidiophoris effusis, brunneis, ramosis; conidiis subglobosis, prima levibus dein verrucosis, pallide brunneis. 10 μ diam.

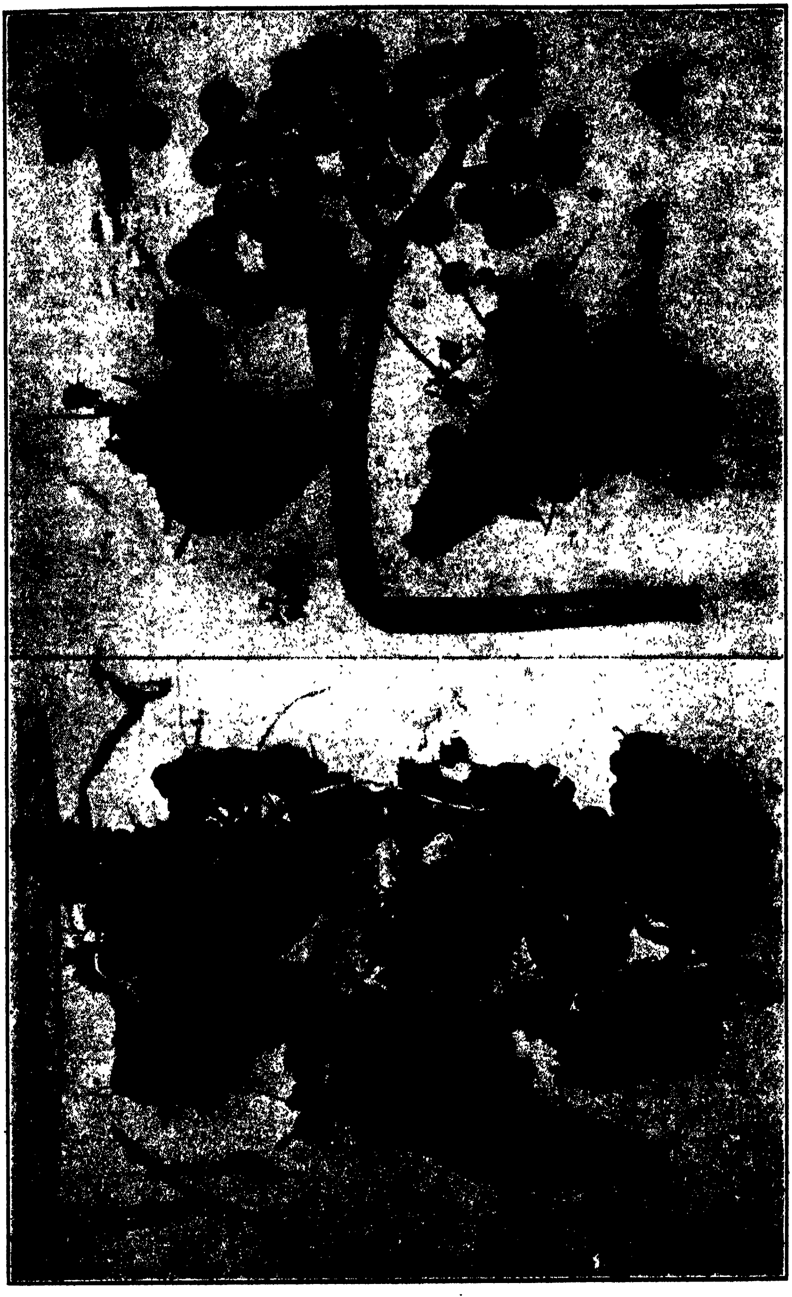

FIG. 1. *Seaverinia Geranii.*

The following is the description and synonymy of the type species:

SEAVERINIA GERANII (Seaver & Horne) Whetzel, Mycologia **37**: 705. 1945.

Sclerotinia Geranii Seaver & Horne, Memoirs Torrey Club **17**: 205–206. 1918.

Stromatinia Geranii Seaver & Horne, Memoirs Torrey Club **17**: 206. 1918.

Conidial stage (*Botrytis Geranii*) occurring on the roots and rootlets of the host, being especially abundant when left in moist chamber for a few days and even developing on the outside of the apothecia, usually appearing in tufts and often springing from minute sclerotium-like bodies although the latter are not always present, dark brown in mass at maturity; conidiophores reaching a length of 1 mm. or more and a diameter of 10–15 μ, pale brown, sparingly septate and branched, the conidia borne in rather large masses like bunches of grapes; conidia subglobose or pyriform, the small end representing the point of attachment, reaching a diameter of 10 μ or rarely as large as 12 μ, slightly longer than broad, at first smooth, becoming quite strongly roughened, pale brown with transmitted light. Apothecia springing from the partially decayed rootstocks in clusters of variable numbers, stipitate, shallow cup-shaped or subdiscoid, reaching a diameter of 1 cm. or rarely larger, pale brown externally; hymenium concave or nearly plane, a little darker than the outside of the apothecium; stem reaching a diameter of 2 mm. and often reaching a length of several cm., though often short and occasionally almost wanting, the length varying with the depth to which the rootstocks of the host are buried; asci cylindric or subcylindric, 8-spored, reaching a length of 120–140 μ and a diameter of 8–10 μ; ascospores hyaline, ellipsoid or almond-shaped, 4–5 × 12 μ, usually containing two small oildrops (FIG. 1).

On the rootstocks of wild geranium (*Geranium maculatum*). The type collected in woods in the upper end of Van Cortlandt Park, New York City, 1917.

DISTRIBUTION: New York and Wisconsin.

ILLUSTRATIONS: Memoirs Torrey Club 17: *p. 13;* Mycologia 37: *704, f. 32, 33.*

NEW YORK BOTANICAL GARDEN,
BRONX PARK, NEW YORK

EXPLANATION OF FIGURE 1

Above, photograph of clumps of *Botrytis* on the underground parts of wild geranium, natural size, with drawings of conidiophores, and conidia enlarged.

Below, photograph of a clump of apothecia, natural size, with drawing of ascus with ascospores and several germinating ascospores, much enlarged.

All drawings made with the aid of the camera lucida to a common scale.

ANOTHER GYMNOSPORANGIAL CONNECTION

Frank D. Kern and Erdman West

(with 3 figures)

Cultural proof of heteroecism in the Uredinales was made by deBary in 1864 and the fact that species of *Gymnosporangium* were heteroecious was proved very soon afterwards. In the spring of 1865 Oersted demonstrated by controlled inoculations the connection between *Gymnosporangium Sabinae* on red cedar and *Roestelia cancellata* on pear. During the next two years Oersted proved the life-history of *Gymnosporangium juniperinum* and of *Gymnosporangium clavariaeforme.* We are indebted to Oersted as well as to deBary for pioneer work with the heteroecious rusts.

Since those early days cultures by different workers have demonstrated the life-histories of many other species of *Gymnosporangium.* The telial stages are on members of the cedar family, Juniperaceae. For many species the aecial stages were found to occur on members of the apple family, Malaceae. At one time it was thought safe to conclude that the species of *Gymnosporangium* inhabited only hosts belonging to the families Juniperaceae and Malaceae. No telial stages have been found outside the Juniperaceae but aecial stages of three species are now known to be on hosts belonging to the Rosaceae, Hydrangiaceae, and Myricaceae, respectively.

There are a few species on the members of the apple family having cupulate aecia and aeciospores with pale yellow walls. The majority of these species, however, have aecia with a cylindric or cornute peridium, peridial cells with walls variously sculptured, and aeciospores with deeply colored walls. In general these are the characteristics of the form-genus *Roestelia.*

Two species of *Roestelia* have stood apart from the majority in having smooth peridial cells. One of these was described by Schweinitz as *Caeoma* (*Roestelia*) *Botryapites* on *Amelanchier* *canadensis*. In 1886 Thaxter (Bot. Gaz. 11: 236) established the relationship between this *Roestelia* and *Gymnosporangium biseptatum* Ellis on *Chamaecyparis thyoides*.

The other species, having smooth peridial cells, was named *Roestelia hyalina* by Cooke in 1877 (Bull. Soc. Bot. Fr. 24: 315) from a specimen on *Crataegus* from South Carolina. For many years nothing further was known about this species. It did not appear in mycological collections and we find no published references to it until 1910. In that year the senior author reported (Science 31: 832) finding it on some herbarium specimens at the New York Botanical Garden and the Arnold Arboretum. This discovery showed that its occurrence was not rare and extended the range northward to North Carolina and southward to Florida. The ten species of *Crataegus* on which it was found are listed in "A Biologic and Taxonomic Study of the genus Gymnosporangium" (Kern, Bull. N. Y. Bot. Garden 7: 470. 1911); in the North American Flora (7: 207. 1912); and in Arthur's Manual of the Rusts of the United States and Canada (p. 361. 1934).

In the Science paper, quoted in the foregoing paragraph, which was entitled "Prediction of Relationships among some Parasitic Fungi," the senior author speculated on the life-history of *Roestelia hyalina* on *Crataegus*. It was there pointed out that it had two striking characters in common with *Roestelia Botryapites* on *Amelanchier*, (1) the entirely smooth walls of the peridial cells, and (2) the small wart-like protuberances in which the peridia are borne, and the conclusion was that these two forms might be related to similar telial stages. Since *R. Botryapites* was known to be connected to *G. biseptatum* on white cedar (*Chamaecyparis thyoides*) the prediction was that *R. hyalina* ought to alternate with a telial stage on the white cedar and an argument was presented in favor of the only other rust then known on that host, *G. Ellisii*. However, in 1914 Fromme established the relationship of *G. Ellisii* with an aecial stage on *Myrica*. In 1911 the senior author described another rust on white cedar, *G. fraternum* (Bull. N. Y. Bot. Garden 7: 439). In 1916 Dodge demonstrated that *G. fraternum* has *R. transformans* on *Aronia* as its alternate stage (Bull. Torrey Club 45: 297. 1918).

As we resumed interest several years ago in *Roestelia hyalina* on *Crataegus* we were mindful of the white cedar hypothesis. The three species of *Gymnosporangium* then known on white cedar being associated with aecia on *Amelanchier, Myrica,* and *Aronia,* it was obvious that a new one had to be discovered if that hypothesis were correct.

The first field observations were made in South Carolina. In the summer it was easy to find *R. hyalina* on *Crataegus* in the region of Aiken. *Chamaecyparis* was not found growing in the vicinity of the *Roestelia* and there arose a considerable doubt about the probability of its being the alternate host. A gall form on red cedar was found which was thought to be a possibility. It resembled *Gymnosporangium globosum* but seemed to have minor differences which we thought might be significant. In 1940, the same form was found near Bristol, Florida, where *R. hyalina* is commonly present on *Crataegus quaesita* later in the year. At least two seasons were lost while we were settling the identity of this form on red cedar. Cultures finally proved that it was *G. globosum.*

During the war period field work was impossible. In the spring of this year, 1946, we returned to the field convinced that a further search would yield a telial stage on white cedar which would turn out to be the alternate stage of *R. hyalina.* This time we were rewarded. On March 4 the authors, in company with Dr. C. R. Orton, collected at Bristol, Florida, a fine new *Gymnosporangium* on *Chamaecyparis.* Two days later the senior author and Dr. Orton collected the same form in the vicinity of Aiken, South Carolina. We should explain that we had investigated in the meantime the distribution of *Chamaecyparis* and had found that it was known to occur in all the regions of North Carolina, South Carolina, and Florida where the *Roestelia hyalina* was known. Cultures from both the Florida and the South Carolina specimens have produced this *Roestelia* on undetermined species of *Crataegus* in the greenhouses at State College, Pennsylvania. Cultures from the Florida specimens gave positive results on *Crataegus rimosiformis* Murr. and on *C. uniflora* Muenchh. at Gainesville, Florida.

It is true that the name *Roestelia hyalina,* according to the international rules, applying to an aecial "state" had only a "temporary value." It was certain, however, that this aecial "state" would eventually have a "perfect state" in the genus *Gymnosporangium*. In order that it might be included in a monographic presentation with other species of the genus the combination, *Gymnosporangium hyalinum*, was used in the paper "A Biologic and Taxonomic Study of the Genus Gymnosporangium" (Bull. N. Y. Bot. Gard. **7**: 470. 1911). We now have the telial stage ("perfect state") and are supplying the description which makes the name *Gymnosporangium hyalinum* valid. The complete record is as follows:

Gymnosporangium hyalinum [Cooke] Kern, Bull. N. Y. Bot. Gar. **7**: 470. 1911. (FIG. 1.)

Roestelia hyalina Cooke, Bull. Soc. Bot. Fr. **24**: 315. 1877.

Aecidium hyalinum Farlow, Bibl. Index 1: 55. 1905.

Pycnia epiphyllous. Aecia hypophyllous, on small gall-like pyriform protuberances, consolidated at the bases, cylindric, 2–5 mm. high, tardily rupturing along the sides, somewhat distorted but not recurved, the peridial cells lanceolate in face view, remaining straight when wet, outer wall 12–16 µ thick, inner and side walls 3–4 µ, smooth on all surfaces; aeciospores globoid, 19–26 µ in diameter; wall light cinnamon-brown, 2–3 µ thick, finely verrucose, the pores 6–8.

Telia caulicolous, usually on areas extending along the smaller woody branches for 3–6 mm., not causing much swelling, sometimes among the leaves on the green branches, or breaking forth through the bark on larger branches, pulvinate, scattered or usually aggregated, varying in shape and size, 1–5 mm. across or appearing larger by becoming confluent, light chocolate-brown; teliospores 2-celled, ellipsoid, 16–21 × 40–63 µ, slightly constricted at the septum; wall golden-brown, 1–1.5 µ thick, thicker at apex, up to 3–4 µ; pores one in a cell, apical; pedicels cylindrical, 3–5 µ in diameter, moderately long.

HOST PLANTS:

For the aecia: *Crataegus clara* Beadle, Fla.—*C. dispar* Beadle, S. C.—*C. egens* Beadle, Fla.—*C. egregia* Beadle, Fla.—*C. Michauxii* Pers., S. C.—*C. munda* Beadle, N. C.—*C. pexa* Beadle, N. C.—*C. quaesita* Beadle, Fla.—*C. viridis* L., N. C., S. C.—*C. visenda* Beadle, Fla.—*Pyrus communis* L. × *P. pyrifolia* (Burm.) Nakai, Fla.

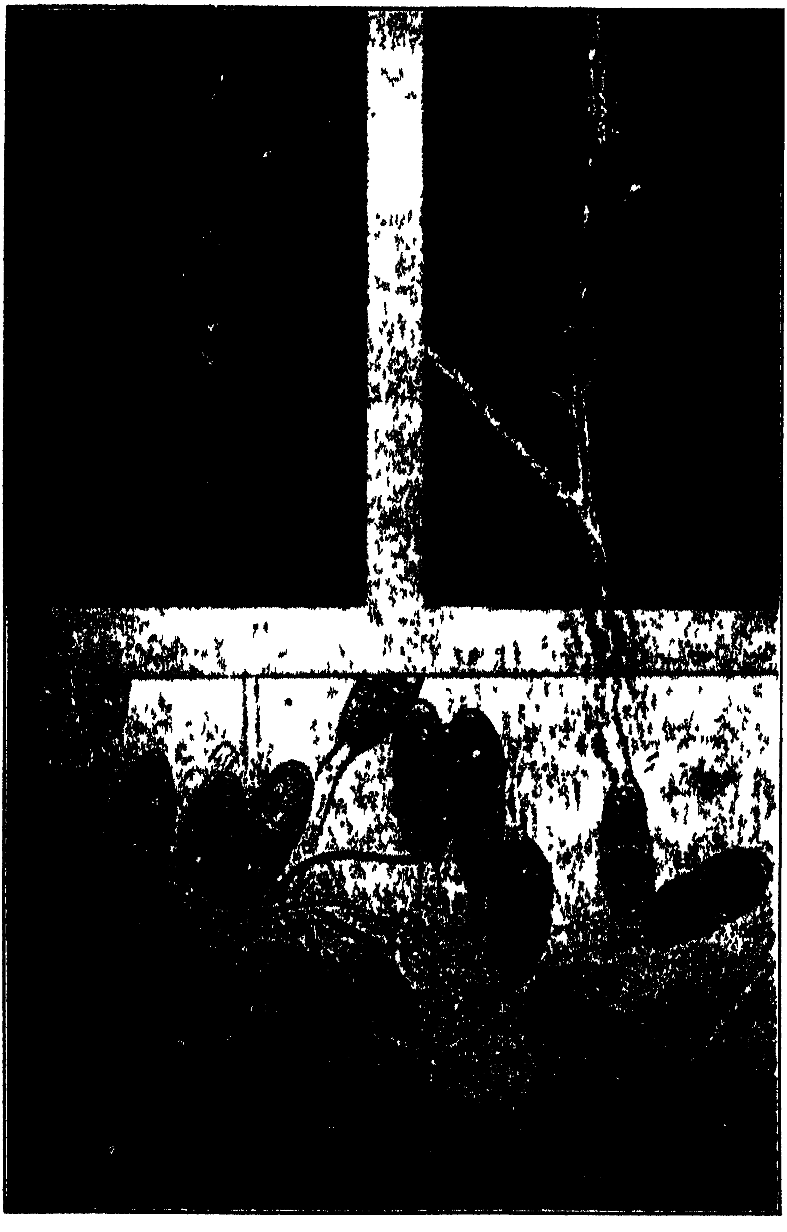

FIG 1. *Gymnosporangium hyalinum*

For the telia: *Chamaecyparis thyoides* (L.) B. S. P., 3½ miles east of Bristol, Fla., March 4, 1946, *F. D. Kern, C. R. Orton, E. West;* Congaree Creek, West Columbia, S. C., March 6, 1946, *F. D. Kern, C. R. Orton.*

THE PENNSYLVANIA STATE COLLEGE,
THE FLORIDA AGRICULTURAL EXPERIMENT STATION

ILLUSTRATIONS

Gymnosporangium hyalinum; above, showing distribution of the telia on branches of *Chamaecyparis thyoides,* below, photomicrograph of the teliospores.

NOTES AND BRIEF ARTICLES

VIABILITY OF SOME MOLD CULTURES

Since there are many laboratories in which a few mold cultures are kept and where no facilities are available for using the lyophil process described by Raper and Alexander[1] for the preservation of mold cultures, it seems warranted to record the following observations since they cover a fairly large number of organisms over a long period of time.

In May 1943 a number of cultures were placed on potato dextrose agar. Care was taken that good sporulation was obtained and that the spores were fully mature before the cotton plugs were ringed with a mixture of glycerol, arsenic and mercuric chloride, placed in baskets and stored in a cold room where the temperature was maintained at approximately 7 degrees C. It was not until January 1946 that the cultures were again transferred. At this time all cultures appeared to be completely dried down but a great many were found to be viable. During my absence in the military service a few cultures were accidently removed and lost. These are listed separately from the nonviable cultures. It should be stated that in a number of cases there are duplications of species. The last group listed as, "others," refers to a number of cultures in which only one of a genus was present or had not been determined. For convenience sake these were summarized under one heading. No attempt was made to determine if there had been any physiological change. The following table shown at top of page 127 summarizes the results.

An interesting thing noted in the genus *Aspergillus* was that species of some sections were definitely more resistant than others. In the *Aspergillus niger* group only two cultures grew out of fourteen, in the *A. wentii* group five were dead out of six, in the *A. flavus-oryzae* group four were dead out of five. On the other hand,

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[1] Raper, K. B. and D. F. Alexander. 1945. Preservation of molds by lyophil process. Mycologia 37: 499–525.

Genus	No. Viable	No. Nonviable	Lost
Mucor	53	1	5
Phycomyces	3	0	0
Rhizopus	13	3	1
Absidia	8	2	0
Circinella	2	0	0
Sporodinia	0	1	0
Mortierella	17	3	2
Haplosporangium	6	1	0
Pilaira	0	1	0
Helicostylum	3	0	0
Thamnidium	2	0	0
Zygorhynchus	5	0	0
Cunninghamella	9	4	0
Syncephalastrum	2	0	0
Syncephalis	0	2	0
Actinomucor	1	0	0
Piptocephalis	0	1	0
Mycotypha	0	1	0
Aspergillus	48	46	4
Penicillium	159	3	2
Fusarium	11	1	3
Trichoderma	7	0	0
Chaetomium	7	1	0
Alternaria	3	0	0
Others	50	12	1
Totals	409	83	18

Total number of cultures reported on, 510.
Total age of cultures, 2 years 8 months.

A. fumigatus and *A. fischeri* group showed the opposite. Of the four cultures of *A. fumigatus* all were alive, while *A. fischeri* showed all eight cultures to be viable. In the *A. versicolor* group all five cultures were viable.

A second set of cultures which were transferred in the summer of 1944 during my absence were tested for viability during February 1946 which represented a period of 19 months. The results were comparable to those above in that the same highest percentage of nonviable cultures were among the Aspergilli and a very low nonviable number of cultures appeared for *Penicillium* and the *Zygomycetes*. For example among the Aspergilli eight were nonviable out of eightly-two. Of course one would expect a greater number of cultures to be alive, which was the case. It is noteworthy that among these were such species as *Pilaira anomala, Sporodinia grandis* and *Mycotypha microspora,* all having been found dead at two years eight months.

It seems especially important among the *Zygomycetes* to observe, prior to storage, that one makes certain that sporulation has been vigorous and that the spores are fully mature since too hasty storage seems to shorten viability. Secondly any culture suspected of being contaminated with *Penicillium* or *Aspergillus* should be reisolated or kept under observation since often a contaminated culture will prove to be dead.

I wish to thank Dr. E. M. Gilbert for making this work possible and for his helpful suggestions.

C. W. HESSELTINE

SCREENING TESTS FOR ANTIBIOTICS

Several thousand microörganisms have been isolated from many sources and tested for antibiotic activity. These microörganisms include fungi, bacteria, Actinomycetes and algae. Mud from the river banks collected immediately after floods was found to be an excellent source of active organisms.

Screening tests for antibiotic activity toward numerous bacteria were conducted using the following medium. All test organisms grew well, and antibiotic compounds were readily produced by this medium.

Dextrose	10.0 grams
Peptone	5.0 grams
Beef extract	3.0 grams
NaCl	5.0 grams
Agar	15.0 grams
Tap or distilled water	1.0 liter

pH adjusted to 7.5 with NaOH before sterilization

1. *Cross-Streak Agar Method*

This method is a slight modification of Garrè's[1] and Fleming's[2] streak methods. In the present work the test consisted of streaking with a wire loop the microörganism to be tested at one side of the agar plate or across its center. A loop-full of thoroughly wetted spores was used to make the streak, to avoid scattering dry and powdery spores over the agar. The cultures were allowed to grow three to five days at room temperature. Usually three days was enough time for any active organism to produce the antibiotic substance which will diffuse into the agar medium. The bacterial testers (using gram-positive and gram-negative bacteria including some human and animal pathogens) were streaked perpendicular to the master streak, without mixing. The bacterial streaks were started close to the master streak then drawn toward the edge of the plate without touching it or breaking the agar. Ruled paper under the plates was used to facilitate streaking. Afterwards the plates were incubated at room temperature (70–90° F.) or at 37° C., sixteen to twenty-four hours and the results observed. Inactive organisms allowed the tester to grow up to the master streak, while the active organisms inhibited the testers in varying degrees. Small petri plates (100 × 20 mm.) containing 20 cc. of medium and large plates (150 × 20 mm.) containing 40 cc. of medium were used. Large plates were more satisfactory when 16 or 20 different bacterial testers were used. Care was taken to select plates with flat bottoms, and not to draw the master streak until the surface of the agar was dry in order to avoid unnecessary spreading of the organism to be tested.

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[1] Garrè, C. Ueber Antagonisten unter den Bacterien. Correspondenz-Blatt für Schweizer Aerzte 17: 385–392. 1887.

[2] Fleming, A. In vitro tests of penicillin potency. Lancet 1: 732–733. 1942

The plates containing active organisms should be kept for several days to determine whether the testers make further growth toward the master streak, whether they remain stationary, or whether lysis of the bacterial testers occurs. It has been found that when the testers grew all the way toward the master streak, the organism was usually void of an antibiotic and was not satisfactory in further work.

Among many bacterial testers used, the following were found useful in the search for organisms with antibiotic activity:

Staphylococcus aureus ATCC No. 6538
Bacillus subtilis ATCC No. 6633
Escherichia coli ATCC No. 9637
Mycobacterium tuberculosis var. *hominis* ATCC No. 607
Bacillus mycoides, Turtox Biol. Supply House, Chicago
Serratia marcescens, Turtox Biol. Supply House, Chicago.

The bacterial testers were grown for one or more days at room temperature or 37° C., on plates or slants of nutrient agar. The growth was scraped off and well mixed in sterile water to make a heavy suspension. Care was taken to scrape off only the bacterial cells and not agar. The testers were also grown in shallow layers of nutrient broth. After seeding, it was sometimes found desirable to shake the flasks occasionally or to set them on a shaker until a heavy suspension of cells was obtained.

2. *Smearing or Flooding Method*

Large as well as small plates were used. The organism to be tested was usually streaked on the agar across the plate passing through its center, and then it was allowed to grow at room temperature for about three days. Then each side of the central streak was smeared or flooded with one or two different testers suspended in sterile water or any other liquid. Usually a gram-negative tester was used on one side and a gram-positive on the other side. When two different testers were used, one side of the plates was flooded first and the excess pipetted off, and as soon as its surface was dry, the other side was seeded in a similar fashion. The plates were then incubated for 16 to 24 hours usually at 37° C.

The flooding technique has been used with helpful results for permanent records. The zone of inhibition (where antibiotic compounds are present) was quite constant for each test organism and for each tester under comparable conditions of media, age, temperature, pH, etc.

The flooding method was used for those organisms which were found to be active and promising by the cross-streak agar method.

A correlation has been found for active organisms between the results obtained with these two methods and the results obtained from shake flasks, aerated bottles, and submerged cultures. Examples of these are *Streptomyces griseus* for the production of streptomycin; *S. lavendulae* for the production of streptothricin and *Penicillium chrysogemum* for the production of penicillin.

FERNANDO CARVAJAL,
SCHENLEY LABORATORIES,
LAWRENCEBURG, IND.

STUDIES IN SCIENCE

Under this title, the University of North Carolina has issued a volume of sesquicentennial publications. All the papers in this volume are original publications of members of the Elisha Mitchell Scientific Society and were first published in the journal of that society as volume 61.

The volume contains the following botanical articles: Penicillin: V. Mycological aspects of penicillin production by Kenneth B. Raper and Dorothy F. Alexander; Nutritional studies of representatives of five genera in the Saprolegniaceae by Alma J. Whiffen; and Revision of the genus *Coleomyces*, parasitic in insect larvae by J. N. Couch.

The entire volume comprises 375 pages, twelve plates and a number of text figures neatly bound in board covers and can be obtained from the University of North Carolina Press.

FRED J. SEAVER

GEORGE GRANT HEDGCOCK

The death of George Grant Hedgcock at the age of 82 occurred near Washington, D. C., on May 11, 1946, after a long illness. Dr. Hedgcock was a pioneer worker in the field of forest pathology and related mycological problems. His work in these fields commenced in 1902 at the Mississippi Valley Laboratory of the Bureau of Plant Industry at St. Louis, where he was particularly concerned with the crowngall diseases of fruit trees and the wood staining fungi. Of the latter he described a considerable number of new species.

After transferring to the Washington office of the then Office of Forest Pathology of the Bureau he was engaged in forest tree disease surveys for some years. In the course of this activity he made the extensive collections of fungi particularly of rusts and wood rotting species which form the basis of the present mycological reference herbarium of the Division. In his latter years he carried on an intensive study of forest tree rusts, especially of the genera *Coleosporium* and *Cronartium*, including life-history studies, and description of new species. His studies in this field were in collaboration with his colleagues, Ellsworth Bethel, W. H. Long, and N. R. Hunt, and resulted in an extensive series of publications. More than 100 titles are included in his complete bibliography.

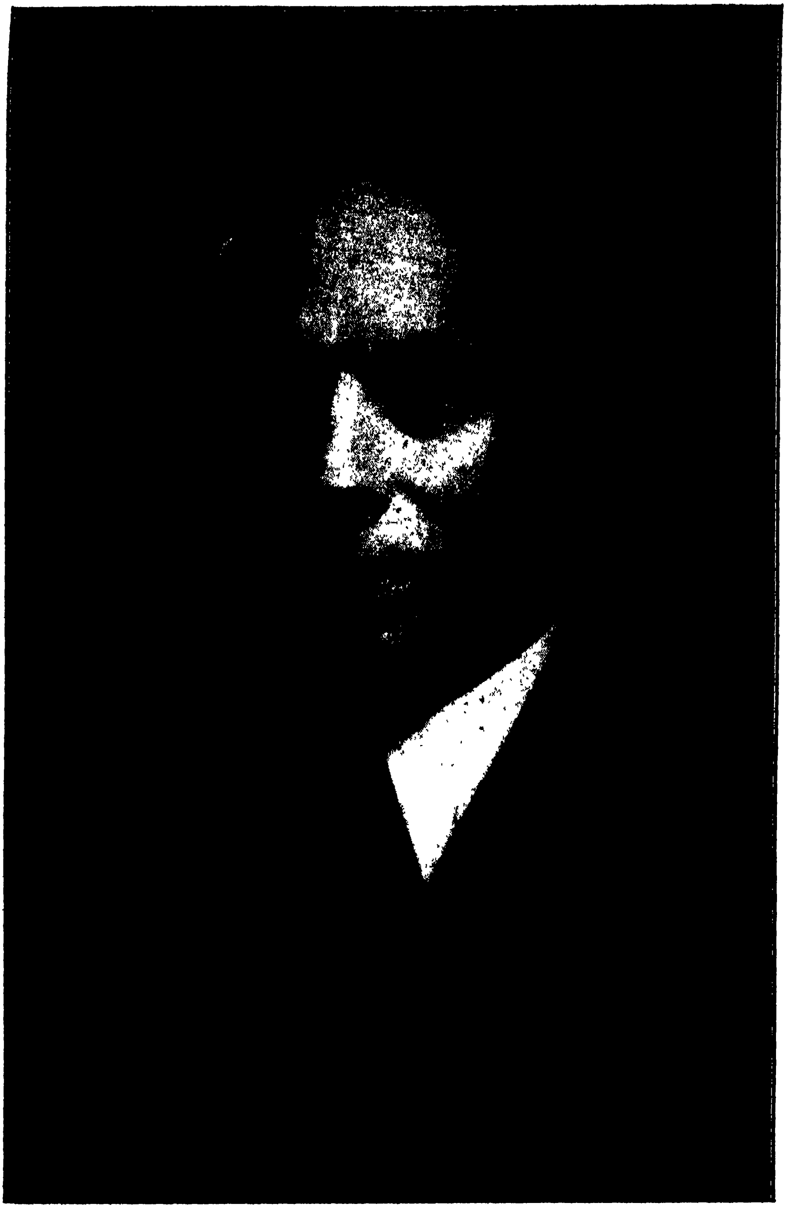
Dr. Hedgcock's private fungus herbarium is being incorporated into the Mycological Collections of the Bureau of Plant Industry.—JOHN A. STEVENSON.

NEW COMBINATIONS

The following species described by me under *Cortinaria* and *Lactaria* in MYCOLOGIA, Lloydia and the Torrey Bulletin from 1938 to 1945 are here recombined under *Cortinarius* and *Lactarius* for the convenience of those who prefer to use the masculine form of the generic names.

Cortinaria albidiformis Murr. = **Cortinarius albidiformis** Murr.
Cortinaria amarissima Murr. = **Cortinarius amarissimus** Murr.
Cortinaria atribadia Murr. = **Cortinarius atribadius** Murr.
Cortinaria campestris Murr. = **Cortinarius campestris** Murr.
Cortinaria citriniceps Murr. = **Cortinarius citriniceps** Murr.
Cortinaria cylindrispora Murr. = **Cortinarius cylindrisporus** Murr.
Cortinaria deflexa Murr. = **Cortinarius deflexus** Murr.
Cortinaria equestriformis Murr. = **Cortinarius equestriformis** Murr.
Cortinaria fimbriata Murr. = **Cortinarius fimbriatus** Murr.
Cortinaria hebelomoides Murr. = **Cortinarius hebelomoides** Murr.
Cortinaria lacticeps Murr. = **Cortinarius lacticeps** Murr.
Cortinaria largiformis Murr. = **Cortinarius largiformis** Murr.
Cortinaria oreades Murr. = **Cortinarius oreades** Murr.
Cortinaria perviolacea Murr. = **Cortinarius perviolaceus** Murr.
Cortinaria privigniformis Murr. = **Cortinarius privigniformis** Murr.
Cortinaria pusilla Murr. = **Cortinarius pusillus** Murr.
Cortinaria squalidiformis Murr. = **Cortinarius squalidiformis** Murr.
Cortinaria subcamphorata Murr. = **Cortinarius subcamphoratus** Murr.
Cortinaria subfimbriata Murr. = **Cortinarius subfimbriatus** Murr.
Cortinaria subglobispora Murr. = **Cortinarius subglobisporus** Murr.
Cortinaria sublilacina Murr. = **Cortinarius sublilacinus** Murr.
Cortinaria viscibadia Murr. = **Cortinarius viscibadius** Murr.
Cortinaria Watsonii Murr. = **Cortinarius Watsonii** Murr.
Cortinaria Weberi Murr. = **Cortinarius Weberi** Murr.
Lactaria alachuana Murr. = **Lactarius alachuanus** Murr.
Lactaria amarissima Murr. = **Lactarius amarissimus** Murr.
Lactaria arcuata Murr. = **Lactarius arcuatus** Murr.
Lactaria avellanea Murr. = **Lactarius avellaneus** Murr.
Lactaria Buckleyana Murr. = **Lactarius Buckleyanus** Murr.
Lactaria nonlactiflua Murr. = **Lactarius nonlactifluus** Murr.
Lactaria paradoxiformis Murr. = **Lactarius paradoxiformis** Murr.
Lactaria parvula Murr. = **Lactarius parvulus** Murr.
Lactaria praeviscida Murr. = **Lactarius praeviscidus** Murr.
Lactaria praezonata Murr. = **Lactarius praezonatus** Murr.
Lactaria sublata Murr. = **Lactarius sublatus** Murr.
Lactaria subtestacea Murr. = **Lactarius subtestaceus** Murr.
Lactaria torminosa glabra Murr. = **Lactarius torminosus glabrus** Murr.
Lactaria Westii Murr. = **Lactarius Westii** Murr.

W. A. MURRILL



David Hunt Linder, 1899–1946.

MYCOLOGIA

OFFICIAL ORGAN OF THE MYCOLOGICAL SOCIETY OF AMERICA

VOL. XXXIX MARCH–APRIL, 1947 No. 2

DAVID HUNT LINDER

September 24, 1899—November 10, 1946

PHILIP L. RUSDEN

Men of science turn instinctively from the path of least resistance so plainly marked by the signposts of emotional reactions. David Linder was first of all a scientist, outstanding in his ability as one of the leading mycologists of his time. True to his science his work shows an ingrained distrust of purely emotional responses. His fellow mycologists, however, in weighing the promise of a life but partially fulfilled cannot do so in the cold dispassionate balances of the laboratory. The still-felt warmth of his sincere, friendly and responsive personality makes foolish any attempt to exclude a deep feeling of loss through his untimely death. A brief sketch of his life and work as a mycologist and a review of his trusteeship as Curator of the Farlow Herbarium and Reference Library at Harvard University should refresh the memories of fellow-workers who were close to him and, for those not fortunate enough to have known him well, should turn a bright page in the history of botanical science.

David Hunt Linder was born in Brookline, Massachusetts, September 24, 1899. Most of his early childhood, however, was spent in the rural town of Canton. His early opportunities for observation of Nature made indelible impressions that time intensified. David Linder's parents did much to foster a love of plant life in their children; indeed, his father was more in love with botany and horticulture than with his profession as a chemist.

[MYCOLOGIA for January–February (39: 1–132) was issued March 7, 1947]

The Linder home in Canton had, besides a conservatory, a greenhouse and extensive gardens of flowers and vegetables, a considerable acreage of wild and cultivated shrubs and trees. The influence of that ideal situation remained with David Linder all of his life.

There was a typical country schoolhouse near the Linders' on York Street in Canton where David and his brothers went for a year or two. In later years they referred to it with affectionate hyperbole as "York University." Leaving the little schoolhouse David Linder went to Noble and Greenough School for Boys, at Dedham, Massachusetts, to complete his basic education. He entered Harvard College in 1917 and as an undergraduate passed the period of World War I in the S.A.T.C. with a limited chance to assist the war effort in chemistry and a brief but long-remembered acquaintance with "close-order drill." A mild distaste for the military mind, expressed during the recent world conflict, was attributable to the sergeant who guided the erring feet of his unit in the paths of military righteousness.

Receiving his A.B. from Harvard College in 1921 he applied himself to graduate study in his chosen field of mycology. This was from no sudden whim for, in addition to encouragement he received from his father, he was also much indebted to his great-uncle, William Gilson Farlow, for guidance. Dr. Farlow died while David Linder was an undergraduate; nevertheless there are letters to show that they exchanged ideas regarding the identity of fungi even before David Linder entered college. He often told of visits to his uncle's home in Cambridge and of vacation trips to the summer home near Mt. Chocorua in New Hampshire where Dr. Farlow found him eager for initiation into the mysteries of mycology.

When David Linder had completed his undergraduate studies Mrs. Farlow, realizing that a bit of encouragement is of great value to a young man in getting started in his chosen field, very generously helped to finance part of a trip to Europe and the British Isles. David Linder learned much and made many valuable friends on his visit. Friendships thus formed continued through the years via correspondence and the visits of his European friends to this country.

After receiving his M.A. degree in 1922 he was granted a Sheldon Travelling Fellowship on which he visited British and Dutch Guiana and parts of the British West Indies. This trip gave David Linder a love of the tropics that he carried with him the rest of his life. When, in 1926, upon completion of his requirements for a Ph.D. at Harvard he had an opportunity to go with the Harvard African Expedition to Liberia he jumped at the chance. The going was tough in the jungle and he never fully recovered from the physical strain. To him, however, it was more important that he had once again visited the tropics.

Upon his return from Africa he went to St. Louis, Missouri, as instructor in the Henry Shaw School of Botany at George Washington University and as Mycologist on the staff of the Missouri Botanic Garden. By 1928 he had become Assistant Professor of Botany, retaining the position of Mycologist at the Garden. While working in St. Louis he married Elinor Alberts who served on the staff of the Garden as Orchidologist and later brought her orchid collection to Canton, Massachusetts, when, in response to a lengthy and stimulating correspondence with Professor Weston, David Linder returned to Harvard as instructor in cryptogamic botany in 1931.

While at Missouri his relationship with the director, Prof. G. T. Moore, and the members of his staff was most cordial. He enjoyed all but the teaching. The unfortunate part of the teaching was that although in any informal discussion he was entirely at ease, when "lecturing" he often suffered genuine anguish.

In spite of his repugnance for formal speaking he addressed many science meetings, though the list of societies of which he was a member was more choice than lengthy. He was a charter member of the American Mycological Society of which he was Secretary-Treasurer in 1936–38, Vice-President in 1939 and President in 1940; he was a Fellow of the American Association for the Advancement of Science, Secretary of the Society of Plant Taxonomists, a member of the Torrey Botanical Club, the New England Botanical Club and the British Mycological Society. In American Men of Science his name bears the star that identifies the first thousand men in each major field of science.

While working as Professor Weston's assistant at the Biological Laboratories of Harvard University in 1932 he began his curatorship of the Farlow Herbarium, the same year in which Dr. Thaxter died. This was the year when the economic depression reached its bottom level. Luxury items felt the full effects of a jolted economy and the orchid business established by his first wife was lost.

In 1935 he attended the International Botanical Congress at Amsterdam with Dr. F. J. Seaver. On this trip he reestablished many of the friendships made years before in England and on the Continent. The Congress strengthened his conviction regarding the need for concrete rules of nomenclature in mycology and the importance of strict adherence to such rules.

During the next four years he busied himself more and more with the difficult task of keeping a cryptogamic herbarium and reference library going. His first wife died, whereupon he gave up the family estate in Canton and moved into Cambridge. Characteristically he shared his apartment with a surprising number of graduate students. It was not uncommon to find there nearly a dozen men, mostly mycologists, all of whom will never forget those gatherings.

David Linder was not a man to give way to depression—either mental or economic—but it was with a feeling of relief that his friends learned, in 1939, that he had married again and established a home in Wakefield, Massachusetts. The warm hospitality of the Linder home was opened to a wide circle of friends and acquaintances who were made to feel at ease by the natural charm of his wife, Dorothy, and the delightful atmosphere of informality.

David Linder spent by far the greater part of his life in the academic circle where two men did more than any others to round out his character and to complete his training as a mycologist. Both are outstanding in the field of mycology but beyond that they had very little in common. The first of these, Dr. Roland Thaxter, was rather austere, and somewhat puritanical but with a subdued sense of humor. Since his industry and erudition as the outstanding mycologist of his time were self-evident he was a paramount example for any student. He had little sympathy with mediocrity and none at all with sloppiness. David Linder's mycological drawings attest to the success with which Dr. Thaxter indoctrinated him with his rule of perfection. The other teacher, Dr. Wm. H. Weston, Jr., was the foil for Dr. Thaxter's unbending personality. He too, however, had been a student of Dr. Thaxter's so that for David Linder there was a double-distilled draught of the master-brew of mycological knowledge rendered more palatable by the warmer, approachable nature of Dr. Weston. Nor was Dr. Weston a mere middleman in the deal; he had so much of his own to contribute that he became a guide and mentor within and beyond the limits of their profession. This was quite natural for although Dr. Thaxter could be admired as a great man in his field Dr. Weston was accepted as a companion being but a few years older than David Linder himself. Dr. Weston was largely instrumental in getting him back to Harvard University as Curator of the Farlow Herbarium, to the great benefit of both the Herbarium and the University.

To mycologists the name of David Linder will always be inseparable from the Farlow Herbarium of which he was Curator for fourteen years. He put the collections to work and made them grow in fame and size by his personal effort in a manner that would have won the full approval of William Gilson Farlow.

There are, in round numbers, 980,000 specimens of cryptogams in the cases of the Farlow. Nearly 200,000 of these (about half of them fungi) were added to the collection since 1932. In the same period of time the Herbarium sent out in exchange or for study about 35,000 specimens of fungi and additional other cryptogams to a total of nearly 50,000 specimens. There are still some outgoing and incoming items not accounted for; hence, it is impossible to cite exact figures. There is room enough for astonishment at these rough totals! David Linder maintained the collections for use, not merely for selfish accumulation. He thought of an Herbarium as a Bureau of Standards where the type specimen of a given species serves as a gauge with which to measure others.

Some of the more important cryptogamic collections added to the Herbarium during his curatorship were: the A. M. Scott algae, the Bartholomew fungi, Miss Caroline Hayne's hepatics, his friend Frans Verdoorn's hepatics, the Sprague lichens, Dr. Clarence Cheever's diatoms, Mrs. E. B. Blackford's fungi (including many of Peck's types) and several hundred beautifully executed paintings of higher fungi, also Miss Lizzie Allen's paintings of higher fungi.

As an important adjunct to the dried and preserved material in the herbarium David Linder maintained a living collection of fungi in culture for exchange and study. Of nearly 500 cultures more than 200 were of medical importance.

In the Farlow Library, directly connected with the Herbarium, in 1932 there was reported a combined total of 19,750 books, periodicals, reprints and state or government publications. State and government papers were reported in "volumes" of ten papers each; hence this total actually includes only ten percent of such publications. In spite of the depression, the war, and the generally low state of the Farlow Library exchequer it is encouraging to note that by July, 1946, the total of available items on the shelves had risen to 37,208. The figures show a net increase of 17,458 items during the fourteen years of David Linder's association with the Farlow Library. At the time of his death accessions were at the rate of 1200 per year and did not, so far as possible, duplicate any of the things going to the other libraries of the University. Bare statistics are by no means the whole story. The difficulties encountered in keeping this valuable and important library growing may be read in part in Dr. Linder's annual reports in which he did everything but call down curses on the heads of the Powers That Be to make them see the value of the tools that these books and papers are to the scientist.

Any serious research worker realizes that a library is more than just a collection of books and papers. The items must be reasonably accessible and there must be some system of indexing. Since 1932 there have been added to the shelf-list a total of more than 13,000 author cards and to the subject catalogue more than 26,000 cards. All of these items, so far as possible, refer to authors or works dealing with cryptogamic botany. They are, moreover, additions to a collection of cards, many of them hand-written, that were prepared by Dr. Farlow, Dr. Thaxter and others. Now it is possible for a student to find thousands of items in the literature in a matter of minutes where formerly it took hours. This was accomplished by Dr. Linder working with a staff that would appear woefully inadequate in numbers in institutions of much less importance and of smaller size than the Farlow Herbarium and Library. It is a tribute to the qualities of leadership and tenacity of purpose exhibited by Dr. Linder that even such apparently minor aspects in the progress of the institution were at no time neglected.

During 1939 a catalogue was started that is unique in the annals of cryptogamic botany and of special value to those interested in the personalities that developed the field. Dr. Linder, with the help of Miss Harris, the librarian, has assembled a card index of 2,335 pictures of botanists ranging from group photographs to formal portraits, including 1,588 individuals and 747 duplications.

David Linder often spoke of the need for monographic studies in mycology. In 1943, in the first number of Farlowia came the realization of the kind of journal he had in mind as a vehicle for monographic articles. He was very largely instrumental in its publication and, as editor-in-chief, in his foreword to the first number, he said . . . "most journals are published by academies, societies or institutions which for the most part must limit the privilege of publication to their members. . . . To remedy this situation and to make possible the publication of longer taxonomic papers it has been decided to publish (Farlowia) . . . which . . . will include articles up to one hundred pages in length and that deal with . . . the classification of the non-vascular cryptogams." Thus was launched a quarterly journal, a valued companion publication to Mycologia and a memorial both to William Gilson Farlow and to his distinguished grand-nephew and successor, David Linder.

In the Report of the President of Harvard University, 1935–36, Dr. Linder wrote, "As matters stand today, the only two members of the staff who are trained to do scientific work and publication are burdened with routine work. . . . Under such conditions it is impossible for the staff to publish papers . . . since only the briefest papers may be put together in the occasional scattered moments that are available for research. . . ." These same words could still have been used ten years later. Indeed, he did use almost identical words each year in pleas for more funds and more time for study. It is a matter of pride to botanists, however, that the list of publications of which David Linder was the author or co-author in the years since 1936 shows how well those "occasional scattered moments" for research were used. He always looked forward to budgets commensurate with the endeavor they support and to hours of study to free capable men from the petty cares of counting-house clerking. It is noteworthy that in all of his pleas for time and funds his first thought was for the furtherance of science and the helping of *other* scientists.

While David Linder was curator the Farlow Herbarium produced almost an even one hundred and fifty scientific papers contributing to the knowledge of cryptogamic plants, principally the fungi. Of this impressive number he was personally credited with nearly one-fourth. This is the more remarkable when the burden of administrative duties is considered, and when it is realized that he had virtually no stenographic assistance in an extensive correspondence, and that he was continually busy with the identification of specimens sent to the herbarium. As if these duties were not burdensome enough to have consumed the time of two less energetic men he added to them the teaching of courses, the preparation of papers delivered at meetings of the Mycological Society, and the special instruction of many graduate students, who, in a number of cases, were not assigned to him but who, once having received help or advice, kept coming back to the one upon whom they learned to depend as an unfailing source of help in any matters pertaining to the fungi. Where then did he find the time for his beautifully executed drawings? In these extraordinarily well-wrought illustrations he carried on the tradition of the Harvard Cryptogamic Laboratories as established by the brilliant work of Roland Thaxter.

As a mycologist David Linder explored many parts of a broad field and acquired a perspective denied to many specialists. He pioneered in several unrelated branches of mycology. His "Monograph on the Helicosporous *Fungi Imperfecti*" was, to a large extent, pioneering and, backed by his subsequent contributions to this fascinating hinterland of the fungous world, he expanded considerably the arc of a hitherto much restricted mycological horizon. When he made a study of the marine fungi (with E. J. Barghoorn) he found himself literally in uncharted mycological waters where the taxonomic problems would have dismayed a less capable man. A posthumous paper on the fungi of the Canadian Sub-Arctic will show the pioneering urge still carrying him toward new horizons of mycological knowledge.

Bare statistics tell but little, yet there are not many men who in less than a quarter century, in addition to duties that many might consider full-time work in themselves, could ferret out, describe, compare, measure, draw, and establish one new family of fungi, sixteen new genera, and one hundred seventy new species or combinations. Here indeed was a young man to refute the pessimism of those who see no good except in the dim past. By his example David Linder has shown the men of the coming generation what can be done.

He was intensely patriotic in the best sense of the word and proved his patriotism handsomely in the recent world conflict as a citizen and as a mycologist. Many mycologists will remember that in his address as retiring President of the Mycological Society he opened on a patriotic note when he urged the members of the Society . . . "as mycologists . . . to serve our country . . . and still continue to add to the knowledge of our subject. . . ." This admonition preceded the Japanese attack on Pearl Harbor and our entry into the war by several months.

His own contribution was made at considerable self-sacrifice at a time when he suffered a good deal of illness. For his work the U. S. Quartermaster Corps was more than grateful. Dr. Weston who was closely associated with him in that work will do full justice to the subject in a forthcoming paper in Farlowia.

It is recommended that members of the Mycological Society re-read David Linder's address as retiring President of the Society. In addition to his expression of patriotism there is a good deal else in the address that gives additional insight into David Linder, the mycologist. He discussed the value of taxonomic mycology to keep the plant pathologist, the medical mycologist and others from the brink of nomenclatorial chaos. He defended Latin diagnoses, not that he believed the International Rules immutable just because they are *rules,* but rather that they should be followed strictly until such time as they might be changed by due process of law rather than by whim.

David Linder's published works, representing in part his contribution to the science of cryptogamic botany, will stand as an enduring memorial to his name.

U. S. DEPARTMENT OF AGRICULTURE,
206 FEDERAL BLDG.,
CAMBRIDGE 39, MASSACHUSETTS,
DECEMBER, 1946

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PRODUCTION OF TELIOSPORES AND UREDOSPORES OF PUCCINIA GRAMINIS ON BERBERIS CRETICA IN NATURE *

P. D. Critopoulos

(with 1 figure)

The black stem rust occurs annually on the cereals in Greece and sometimes it is very severe. The alternate host of this rust is *Berberis cretica* which is the only species of the family *Berberidaceae* growing wild in this country. Its habitat is on mountains from 800 m. to subalpine regions in Macedonia, Thessaly, Eubœa, Attica, Laconia, and Crete. *Berberis cretica* is annually attacked by *P. graminis*; however, so far it has not been proved that it plays an indispensable part in the life cycle of the black stem rust. If the bush formation of this alternate host on the mountain tops is really a source of inoculum for the cereals in the plains, then a program of eradication would have to be considered. This problem however is not answered in the present paper. Instead an interesting fact is recorded, namely, the finding of teliospores and urediospores of black stem rust on the alternate host. In this connection I desire to give due recognition for guidance to my honored Professor Frank D. Kern of the Pennsylvania State College, U. S. A.

The infection of *B. cretica* by *P. graminis* has been known for a long time. Stakman (**1923**) was one of the first to mention it. Politis (**1929**) also found *B. cretica* infected by the black stem rust of cereals. On the contrary, in west and south Asia Minor the same barberry, which forms more or less extensive formations on the mountains above the tree zone, *i.e.* over 1500 m., has not been found to be attacked. On the leaves the infection consists of yellowish spots one or more on each leaf, in the middle of which first pycnia and then aecia are produced. On the diseased fruits the attack is always severe, the whole surface being covered by aecial cups. Young stems and spines are also attacked. Likewise the short flower and leaf bearing twigs are infected and then all their parts become smaller, thicker, and distorted, being covered all over by aecia.

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* Presented to the Mycological Society of America (by Frank D. Kern for the author) at the St. Louis meeting, March 27, 1946.

The swelling of the diseased parts of the leaves is due to the multiplication and enlargement of the parenchyma cells. In the normal portion of the leaf blade there is only one layer of palisade cells, whereas in the swollen portion there are two or three of these rows. In the parenchyma cells there are oil globules and these are considered to indicate full maturity and exhaustion. The attacked leaves fall from the bushes about the middle of July or in the beginning of August. In wet situations as for example along brooks, the infected leaves may remain on the bushes for a longer time.

Pycnia are formed in the middle of the yellow spots both on the upper and on the lower sides of the leaf blade. Aecia are formed in the middle or scattered all around the yellow spots on the under surface of the blade; often, however, they are found on the corresponding position on the upper surface. The early-developed aecia differ somewhat from those that develop later. The early ones attain a length of 0.2–0.5 mm. and open very soon, whereas the later ones have a length of 1.5–2 mm. and a diameter of 0.1–0.3 mm. The late-appearing aecia are found at the periphery and sometimes they form a row round about the aecia which were produced first; they can be considered as secondary in the same way as in certain instances there are secondary uredia around the primary uredium in the cereals. The aecia which develop late attain their full size during the early part of July. At the bottom and at the top they are somewhat narrower. Often they reach their full length and then the peridium breaks open at the top. The aeciospores are 15–18 × 18–24 μ with finely verrucose walls. The upper side of the wall of the aeciospores sometimes is one-third of the diameter of the spore. Other times it is less than one-third, or it is not evenly thickened, or the thickness may be represented by an internal roundish projection, or it may be thick and at the same time have a projection which reaches to the center of the spore.

In the fully developed aeciospores the orange colored granular content fuses gradually, after about ten days, to bigger particles or forms one big mass. When this occurs their infecting power is lost. If the aeciospores are left in a drop of water in the light, the oily substance loses its orange color in about half an hour, becoming colorless or light grayish-green. It is interesting that in the rows of aeciospores in the aecia, the carotinoids exist in normal proportion in a certain spore, the next spore toward the inside of the cup is entirely colorless. As generally happens with uredia and aecia, the spores in the latter become smaller and their walls attain greater thickness.

The peridial cells have their outer wall 12–14 μ thick which is one-half, or sometimes more, of the radial diameter of the cell. The inner wall is 3–4 μ thick. The walls of the peridium have dark parallel straight lines corresponding with the walls of two adjacent cells. On the outer wall the dark lines are directed toward the outside. Both on the outside and inside the dark lines end in the projecting small protuberances. The inner protuberances in comparison to the outer are somewhat larger. It is supposed that these dark lines are moisture conducting channels. The content of the peridial cells is colored like that of the aeciospores.

The telia are not very abundant. One has to look over many diseased leaves in order to find one. They occur at the edge of the infected yellow spots, on the upper or on the lower side of the leaf blade, or on the other infected plant parts. When covered the telia are blackish brown, when they rupture they are black. They are fairly compact. In form they are more or less round, and about 0.3 mm. in diameter. The telia are formed in the middle of July, just before the leaves fall from the bushes.

The teliospores (FIG. 1) are ellipsoid or oblong-clavate, 18–26 × 34–61 μ, narrowed or rounded above and below, somewhat constricted at the septum, the walls are chesnut-brown, paler below, about 1.5 μ thick at the sides, 5–9 μ above, the pedicels are about as long as the spore. There are also mesospores. The telia occur in such proximity to the aecia that there can be no doubt about the relationship of the two stages. Separate uredia have not been found but a few urediospores have been observed among the teliospores. The urediospores are 18–20 × 22–40 μ. Those that were observed were colorless. The similarity of the teliospores and

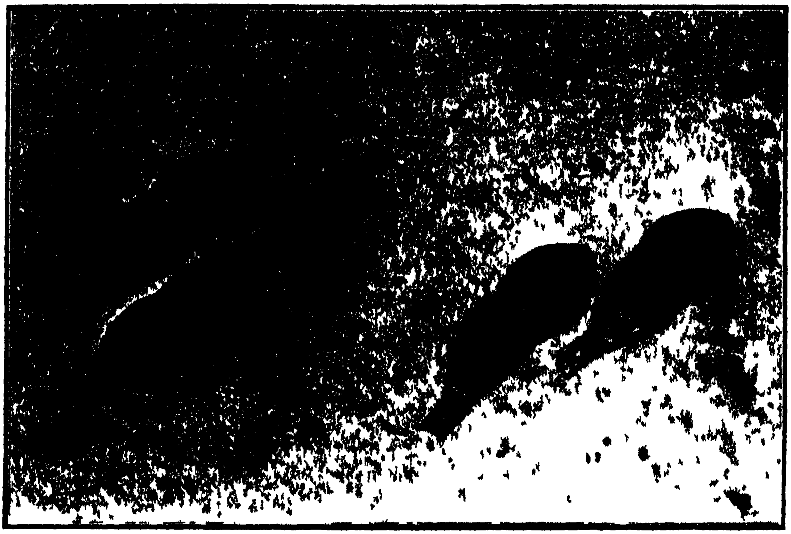

FIG 1. Teliospores of *Puccinia graminis* produced on *Berberis cretica* in nature

urediospores with those of *P. graminis* as ordinarily found on the grass hosts is perfect.

Although the finding of teliospores and urediospores on the alternate host is noteworthy, there is a record of an occurrence similar in some respects. Newton and Johnson (1937) of the Dominion Rust Research Laboratory, Winnipeg, Canada, report that "In the course of greenhouse studies, in which barberry plants were infected with pure cultures of physiological races of *P. graminis tritici* Erikss. & Henn., we have recently observed that two cultures show a distinct tendency to produce uredia and telia on the barberry." The same authors, in a second publication (1938), state that "the production of urediospores and teliospores on the barberry is, perhaps, the most unexpected of the abnormalities described in this paper."

It is interesting that there are some notable differences between the production of the telio- and urediophase on *B. vulgaris* from that on *B. cretica*. On the former, where urediospores and teliospores were produced, pycnia were also produced, but there was always a suppression of aecial formation. This constitutes a brachy-form.

On the latter, pycnia and aecia as well as teliospores and a limited number of urediospores are produced. This constitutes an eu-form. The urediospores produced in the Canadian cultures germinated normally and readily infected wheat seedlings but were apparently unable to infect barberry. Newton and Johnson therefore regarded their strains as still heteroecious. So far as known the present case is the only report of the production of teliospores and urediospores of *P. graminis* on the barberry in nature. The others appeared only in cultures.

In nature there are numerous cases in which a macrocyclic rust (one having the full number of spore-stages) is heteroecious and a microcyclic rust (one which produces pycnia followed shortly by telia or in which pycnia are lacking and only telia are produced) occurs on the aecial host of the heteroecious species with teliospores which are structurally like those of the heteroecious species. Such macrocyclic and microcyclic species are known as *correlated* species. Microcyclic forms may have arisen from the haploid generation of the correlated macrocyclic heteroecious forms through the replacement of the aecia by telia. This view of the origin of the microcyclic forms through reduction from heteroecious macrocyclic forms has been presented by Arthur (1929), Jackson (1931) and others.

Puccinia coronata, the crown-rust of oats and other grasses, has a correlated microcyclic species, *Puccinia mesnieriana.* It occurs on *Rhamnus* which is the aecial host of *P. coronata.* The teliospores of the two are identical, including the crowned projections at the apex. Johnson and Newton (l.c.) state that Dr. G. R. Bisby in private correspondence has pointed out that, in theory, *Puccinia graminis* might have a correlated species with telia on *Berberis vulgaris.* They say it is possible to theorize that the Canadian developments in culture "may perhaps be considered as a tendency on the part of *P. graminis* towards the formation of such a species." The condition on *Berberis cretica* might be interpreted as a step in this direction.

It should be added that there are several microcyclic species of *Puccinia* known on *Berberis,* five from South America and one from Texas. In none of these are the teliospores like those of *P. gram-*

inis. They are not correlated species and therefore need not enter into the present consideration. There is a distinct macrocyclic heteroecious species in Europe with aecia on *Berberis* and uredia and telia on grasses, *Puccinia Arrhenatheri* (Kleb.) Erikss. Since the aecia, aeciospores, and teliospores of this species are different from those of *Puccinia graminis* it cannot have any relation to the present discussion.

As has been stated, *P. graminis* on *B. cretica* has the life history of an autoecious eu-form. In such a form the teliospores and urediospores might develop from a discontinuous diploid generation originating from an aecial infection. In this case it appears that the teliospores and urediospores have developed from the same mycelium which bore the aecia but the evidence is circumstantial. From a genetic viewpoint the production of telio- and urediospores is inherent in the diploid generation of *P. graminis*. Whether it is necessary to assume a changed genic factor to explain their development on the barberry instead of the grass is not clear.

The unusual production of teliospores and urediospores of *P. graminis* on the alternate host, here reported, although not extensive is nonetheless real. Teliospores of this rust produced on the gramineal host do not sustain their vitality during the long period of heat and dryness in the lower altitudes. These spores kept under natural conditions germinate in the spring only 0.5 per cent. It is therefore considered that the production of telio- and urediophase on the alternate host is more or less a successful adjustment on the part of the fungus to produce all spore forms on a host having its habitat at high altitudes where conditions are comparatively more congenial for the sustaining of the germinating power of teliospores.

UNIVERSITY OF ATHENS,
ATHENS, GREECE.

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CHYTRIOMYCES SPINOSUS NOV. SP.

DOLORES J. FAY

(WITH 39 FIGURES)

This chytrid was first isolated from a sample of soil collected in the Pine Barrens in Ocean County, N. J., and subsequently found in rich woodland soil from various parts of New Jersey, New York, Connecticut, and Virginia. In isolating this fungus, the common procedure of covering the soil samples with animal charcoal water and adding bits of lens paper as a substratum was followed. After this substratum became heavily infected, the chytrid was transferred to small pieces of onion skin and grown in virtual unifungal culture in fresh charcoal water to which had been added either a small amount of soil from the original culture or soil water which had been put through a Berkfeld filter.

This monocentric, eucarpic species is characterized by extramatrical, rarely apophysate, operculate sporangia; intramatrical rhizoids attached to a small stalk at the base of the sporangium; posteriorly uniflagellate zoospores which swarm in a vesicle after emerging from the sporangium; and extramatrical resting spores. Accordingly, it belongs in the genus *Chytriomyces*.[1] However, unlike other known species of this genus, it is not markedly chitinophilic and grows more readily on carbohydrate substrata. It differs primarily from *C. aureus* and *C. hyalinus* by the presence of numerous sharp, abruptly-tapering spines which are more or less regularly arranged on the surface of the sporangia and resting spores. Because of this characteristic difference, it is interpreted as a new species and named *C. spinosus.*

Chytriomyces spinosus n. sp.

Zoosporangiis hyalinis, plerumque late pyriformibus 11.3–45 × 11.3–40.5 μ; operculo apicali, vadoso figura ad modum patellae 2.3–6 × 0.75–4.5 μ et apicu-

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[1] **Karling, J. S.** 1945. Brazilian chytrids. VI. *Rhopalophlyctis* and *Chytriomyces,* two new chitinophilic operculate genera. Am. Jour. Bot. **32**: 362–369.

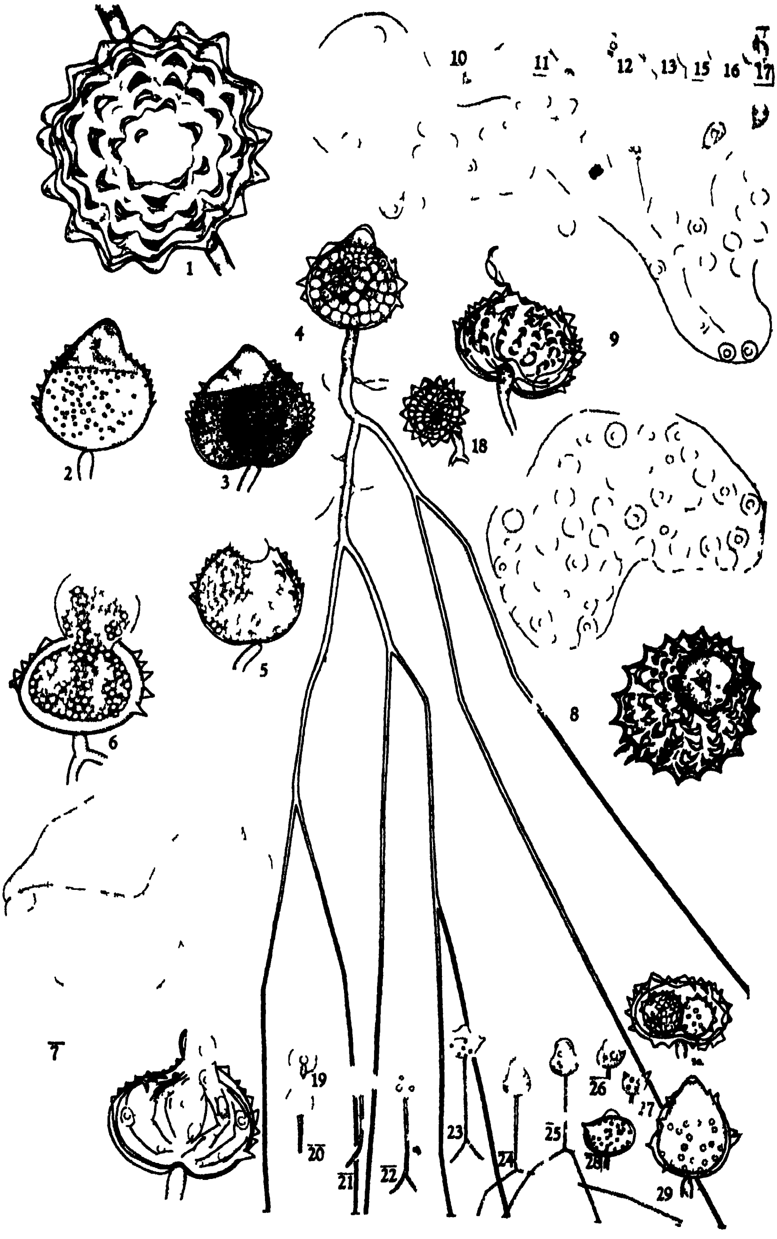

FIG. 1. *Chytriomyces spinosus.*

lato 1.5 × 6.9 μ sporangii pariete 0.75–1.5 μ crassitudine, coopertis plurimus spinis praerupto fastigantibus, generatim simplicibus et solidis 2.5–4.9 × 1.4–5.9 μ raro bifurcatis, aliquando abortivis ad modum paxilli. Rhizoidibus ramosis, generatim emergentibus ab uno principali axi 1.6–3.6 μ diametro et extendentibus longitudine 387 μ. Zoosporis hyalinis, subsphaericalibus 3–4.5 μ parvo medio globulo refractivo hyalino 1.7–2.1 μ diametro; flagello 18–21 μ longitudine. Zoosporis emergentibus et glomerantibus 1–7 punctis temporis in vesiculo hyalino ante effugientibus et enatantibus; vesiculo continuo cum sporangio.

Sporis perdurantibus plerumque ovatis 15–33 × 10–33.5 μ, cuneate 15 × 15 μ raro sphaericali; generatim et impariter coopertis spinis simplicibus vel bifurcatis; pariete hyalino vel parum flavo 1.4–4.5 μ crassitudine; continente unicum globulum olei 6.8 ad 21 μ diametro. Sporis perdurantibus in germinatione ut prosporangia agunt, causantibus parietem tenuem hyalinum subsphaericalem sporangiis levibus secundariis 8.9 ad 20.6 μ diametro.

Zoosporangia hyaline, predominantly broadly pyriform, 11.3–45 × 11.3–40.5 μ, operculum apical, shallow saucer-shaped, 2.3–6 × 0.75–4.5 μ, and apiculate 1.5 × 6.9 μ, wall of sporangium 0.75–1.5 μ in thickness, covered with numerous, abruptly tapering spines, usually simple and solid, 2.5–4.9 × 1.4–5.9 μ, rarely bifurcate, occasionally abortive and peg-like. Rhizoids branched, arising usually from a single main axis, 1.6–3.6 μ diameter and extending to a distance of 387 μ. Zoospores emerge and swarm 1–7 minutes in a hyaline vesicle before escaping and swimming away; vesicle continuous with the sporangium.

Resting spores predominantly ovoid and 15–33 × 10–33.5 μ or wedge-shaped and 15 × 15 μ, rarely spherical; usually covered irregularly with spines which may be simple or bifurcate; wall hyaline or slightly yellowish, 1.4–4.5 μ in thickness; containing a single large oil globule 6.8 to 21 μ in diameter. Resting spores function as prosporangia in germination, giving rise to hyaline subspherical thin-walled, smooth secondary sporangia 8.9 to 20.6 μ diameter.

The life cycle and development of *C. spinosus*, shown in FIGS. 2–30, are fundamentally similar to those of *C. aureus* and *C. hyalinus*. The broadly oval zoospore, with its centrally placed refractile globule, comes to rest, absorbs its flagellum (FIGS. 10–12), and develops a germ tube which penetrates the substratum (FIGS. 19, 20, 21), branches and eventually gives rise to the rhizoids (FIGS. 22–25). At the same time, the extramatrical zoospore enlarges and, as nutriment is absorbed by the rhizoids, develops into a sporangium or resting spore. The characteristic spines begin very early as papillae on the wall of the young incipient sporangium (FIGS. 23, 26, 27) and at first appear very large in proportion to the rest of the zoospore body (FIGS. 27, 28, 29). As is shown (FIGS. 1, 8, 9, 29), they occur frequently over the entire surface of the zoosporangium and resting spore except on the rounded basal portions. Sometimes a spine may occur on the operculum. Usually, the spines on the zoosporangia are simple, solid and abruptly tapering, or they may be comparatively long (FIGS. 4, 6). Occasionally, they are abortive, peg-like, or bifurcate. On the resting-spores, the spines may be more finely drawn out at the tip, bifurcate, irregular, blunt, finger-like, or lacking altogether.

The successive internal protoplasmic changes which occur in the development and maturation of the zoosporangia are so like those described for most of the other monocentric eucarpic chytrids that a detailed description of the process is superfluous. However, one exception has been constantly observed which is worthy of mention. During development a large amount of opaque, optically homogeneous, slimy material accumulates in the apex of the sporangium under the operculum (FIGS. 2, 3, 4). The relative amount of this material varies considerably but, in numerous cases, it may be so great that it fills almost half of the sporangium. In such instances, the zoospore initials with their refractive globules appear to be pushed down into the lower part of the sporangium while the upper part appears relatively empty. When the sporangium dehisces, this slimy substance flows out to form a globular mass at the exit orifice (FIG. 7). As the zoospores emerge, they push up into the mass and expand it (FIGS. 5, 6, 7). By the time most of the zoospores have emerged, the slimy material has been expanded to the extent that it consists of a thin layer around the globular zoospore mass. Present observations indicate that as this layer thins out it becomes transformed into a vesicular membrane within which the zoospores subsequently swarm.

Following emergence from the sporangium, the behavior of the zoospores is similar to that described by Karling (l.c.) for *C. aureus* and *C. hyalinus*. As a result of the rapid swarming of the zoospores within, the vesicle changes rapidly in shape (FIGS. 7, 8, 9), and after 1–60 minutes (usually 1–7 minutes) ruptures in one or several places allowing the zoospores to escape (FIG. 9).

The resting spores of *C. spinosus* are usually ovoid in shape and contain a large refractive globule (fig. 35). The wall varies conconsiderably in thickness, and in living material may sometimes appear to be slightly yellowish-green in color. These spores develop in the same manner as the zoosporangia (figs. 31, 32), and up to a certain stage it is impossible to distinguish between the two. However, by the time the incipient resting spores have reached definitive size, a large amount of refractive material is present in the cytoplasm which gives them a distinctive appearance (fig. 33). As they mature, this material coalesces to form the large refractive globule shown in fig. 35.

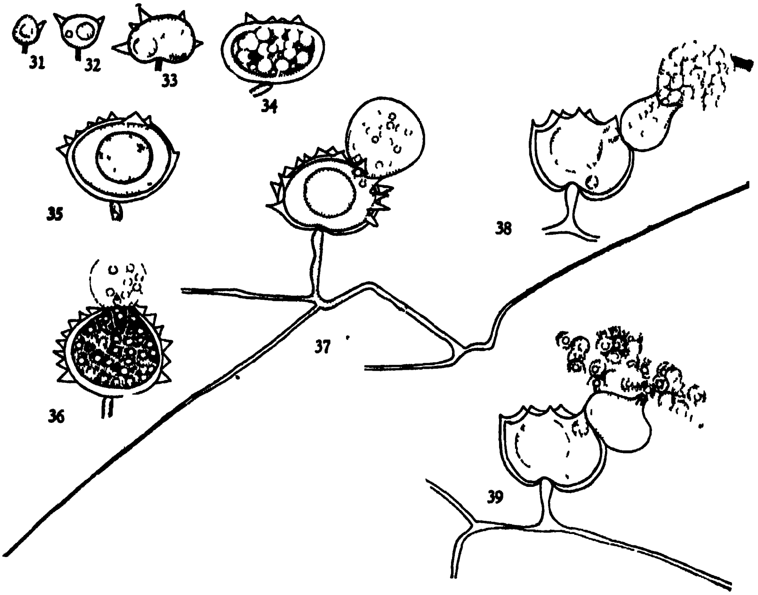

Fig. 2. *Chytriomyces spinosus.*

As in other species of *Chytriomyces,* the resting spores function as prosporangia during germination. As shown in fig. 36, the refractive material becomes more dispersed, a pore is formed in the wall and the protoplasm grows out as a small papilla. This enlarges into a sporangium which remains attached to the resting spore. This secondary sporangium varies considerably in size, but it is usually smaller than the primary sporangia described above.

SUMMARY

Chytriomyces spinosus occurs in nature chiefly on dead and disintegrating vegetation and may be readily cultured on bits of dried onion skin, leaves of grass, filter paper, and other substrata of this type. Unlike *C. aureus* and *C. hyalinus*, it is not markedly chitinophilic in its nutrient requirements. It differs structurally from these species by the presence of numerous abruptly-tapering spines on the surface of the sporangia and resting spores, and by slightly smaller zoospores. Its life cycle and type of development, however, are similar to those of *C. aureus* and *C. hyalinus*.

ACKNOWLEDGMENTS

The author wishes to express grateful thanks to Dr. John S. Karling for assistance in preparing the paper and to Dr. Edwin A. Quain, S. J., for the Latin translation.

EXPLANATION OF FIGURES

All drawings were made with the aid of a camera lucida. Spores enlarged freehand. All other enlargements by pantograph.

Chytriomyces spinosus. FIG. 1 (× 1630), regular arrangement of spines on sporangial surface; 2, 3 (× 480), maturing sporangium showing subapical slimy substance; 4 (× 560), mature thallus; 5, 6, 7, 9 (× 560), 8 (× 750), progressive stages in formation of the vesicle and emergence of the zoospores; 10–17 (× 800), curling and retraction of the flagellum, and germ-tube formation by zoospore; 18 (× 375), undischarged zoosporangium; 19–22 (× 800), *anlage* of rhizoids; 23 (× 800), 24 (× 1290), young papilla; 25 (× 1290), operculum; 23, and 26, 27 (× 560), refractile globules in young sporangium before dispersion; 30 (× 375), two undischarged zoospores developing within collapsed primary zoosporangium.

(Following figures all × 560): 31, 34, young stages of the developing resting spores; 35, mature ovoid resting spore with large refractive globule; 36, dispersion of the material in the mature resting spore followed by germination of the latter; 37, resting spore functioning as a prosporangium; 38, 39, germination of secondary sporangium.

THE EFFECT OF TEMPERATURE AND RELATIVE HUMIDITY ON THE LONGEVITY OF THE CONIDIA OF *HELMINTHOSPORIUM ORYZAE* *

ROBERT M. PAGE, ARDEN F. SHERF AND THOMAS L. MORGAN

(WITH 1 FIGURE)

Brown spot of rice caused by *Helminthosporium oryzae* van Breda de Haan is a disease of importance wherever rice is grown. It causes most damage as a seedling blight, but may lower the yields of more mature stands to some extent by leaf lesions which reduce the effective photosynthetic areas of the leaves. On kernels, brown spot produces lesions which impair the milling quality of rice as well as the yield. Control of the disease consists mainly of seed treatments (Nisikado and Miyake, **1920**, Lin, **1936**) and field sanitation (Wei, **1936**).

Secondary spread of the disease is brought about by conidia which are banana-shaped, 5–9 celled reproductive bodies 80–130 μ long by 16–22 μ wide. *Helminthosporium oryzae* has been shown to possess extensive longevity in culture. Nisikado (**1922**) reported keeping it in culture for 943 days without transfer after which it resumed growth when fresh medium was added. Wei (**1936**) found that infested portions of rice plants could be stored on trees, on soil and underground for considerable periods without loss of viability by the fungus. In no case, however, has it been clear whether the vegetative mycelium or the conidia were responsible for the persistence, and the conditions of storage were not controlled.

Since *H. oryzae* produces large numbers of conidia on the leaves and heads of infected rice plants during favorable weather conditions, it was of interest to learn something of the longevity of the conidia under various environmental conditions. Therefore experiments of two types were conducted to determine first, the effect of temperature, and second, the effect of both temperature and relative humidity combined on the longevity of the conidia.

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* Results of investigations conducted at Camp Detrick from May, 1944 to December, 1944.

EFFECT OF TEMPERATURE

The conidia used in the experiments were produced by growing *H. oryzae* on moistened sterilized oats. Three hundred grams of oats in Fernbach flasks were moistened with 345 ml. of water, steamed for 30 minutes and autoclaved at 15 lbs. pressure for 20 minutes. The flasks were then allowed to stand over night and reautoclaved. After the flasks cooled, they were inoculated with an aqueous suspension of conidia and incubated for 14 days at 22–24° C. in the dark. The conidia were left in contact with the substratum, and the contents of the flasks were dried in a steam oven for 24 hours at 40° C. One to two grams of infested oats were placed in small vials closed with screw caps. The vials were stored at various temperatures and the viability of the conidia determined periodically.

The viability of the conidia was measured by making germination counts. The conidia were removed from the containers with a sterile loop and placed in a drop of sterile water on the surface of potato-dextrose agar in a Petri dish. The suspension was streaked

TABLE 1

VIABILITY (*expressed as per cent germination*) OF CONIDIA OF HELMINTHOSPORIUM ORYZAE STORED AT VARIOUS TEMPERATURES

Length of Storage (Days)	Temperature (° C.)					
	2°	10°	21°	RT*	27°	31°
7	91	90	93	92	93	91
15	89	74	78	83	82	89
22	91	88	85	85	90	89
28	89	81	80	81	87	73
40	90	85	80	76	73	63
48	92	85	67	67	74	29
60	93	79	60	69	57	19
70	93	82	56	73	63	30
81	87	85	45	71	73	26
90	97	85	47	74	81	15
100	81	66	17	56	42	6

* Room temperature approximately 24° C.

over the surface of the agar and the conidia allowed to germinate for four hours. A total of approximately 200 conidia, germinating and ungerminated, was then counted with the 16 mm. objective and the percentage of germinating conidia calculated. The results (TABLE 1) indicated that the conidia retained their viability best when stored at low temperatures. At the end of the experiment, after 100 days storage, 81 per cent of the conidia stored at 2° C. were viable, whereas only 6 per cent of those stored at 31° C. were capable of germinating. Although there was some irregularity and inconsistency in the results, the trends were clear. Some of these irregularities may have been due to the differences in relative humidity of the various places of storage, since the screw caps on the vials did not completely prevent air exchange.

EFFECT OF TEMPERATURE AND RELATIVE HUMIDITY

The method of producing conidia to test the effect of temperature and relative humidity combined was the same as that described in the preceding section. The conidia were removed from the substratum by several successive portions of water which were added to the flasks and then shaken vigorously. The resulting suspension was strained through wire gauze to remove the seeds, poured into cylinders and allowed to settle over night at 8° C., a temperature sufficiently low to preclude germination of the conidia during the settling process. After the supernatant liquid was decanted, the conidia were collected on coarse filter paper in a Buchner funnel. The filter cake was broken up and dried at 40° C. for 24 hours.

For the experiments in which the relative humidity was controlled, small samples (of the order of 20 mg.) of conidia were placed in 15 × 150 mm. test tubes which had been cut to a length of approximately 90 mm. Each test tube was placed in a half pint milk bottle which was closed with a waxed cardboard disk. The relative humidity within the bottles was regulated with sulfuric acid solutions (Stevens, 1916). The acid solutions were adjusted to provide the correct vapor pressure at 25° C., and were not corrected for differences in storage temperatures, since the temperatures used would change the relative humidity less than two per cent from the desired value. In this experiment the conidia were stored over acid solutions which provided four relative humidities: 20%, 45%, 70% and 95%. Temperatures were controlled by placing the containers in constant temperature rooms which were thermostatically regulated within two degrees centigrade of the desired temperature. Germination counts were made periodically as described previously.

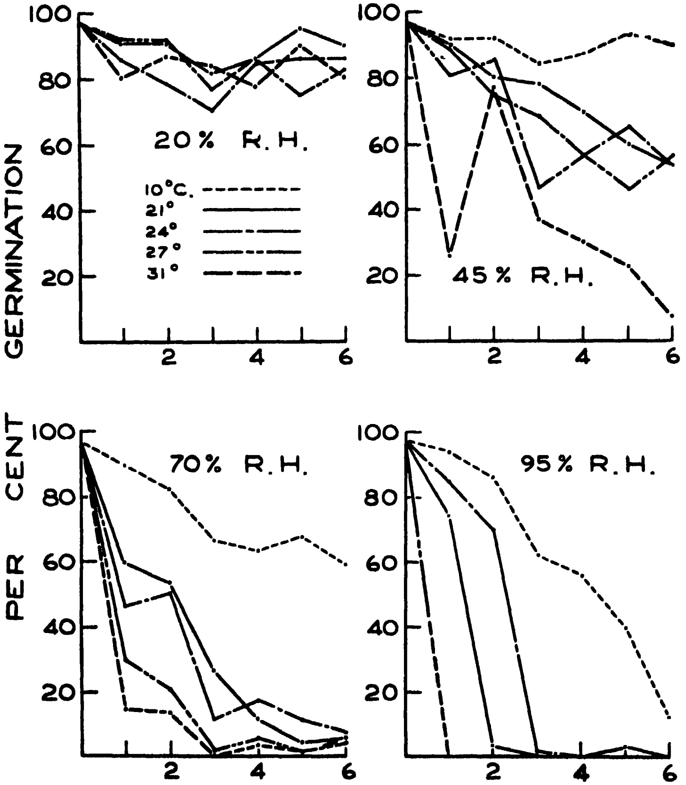

FIG. 1. Graph showing the viability of conidia of *Helminthosporium oryzae* stored at relative humidities of 20, 45, 70 and 95 per cent at various temperatures.

The results (FIG. 1) showed that the relative humidity during storage was a more important factor influencing longevity than temperature alone. For example, at 20 per cent relative humidity the conidia survived for six months with little loss of viability even at 31° C., whereas at 95 per cent relative humidity they failed to germinate after one month at 31° C. Viability was retained best at low temperatures at all relative humidities.

DISCUSSION

The results obtained agreed in general with those of Peltier (1925) who found that with the urediospores of *Puccinia graminis tritici* the lower the temperature the longer the spores retained their viability at all relative humidities. A similar relationship was found with the flag smut of wheat, *Urocystis tritici* Koern., the spores of which remained viable longest at low relative humidities. Noble (1934) found that the spores of this fungus would retain their viability for at least ten years when stored at relative humidities below 33.5 per cent at uncontrolled temperatures which ranged from 13 to 31° C. The results obtained with *H. oryzae* were in contrast to those obtained with the conidia of the downy mildew of tobacco which remained viable longest (two months) under cool, moist conditions (3°–5° C., 60–80% relative humidity) according to Angell and Hill (1931).

The importance of relative humidity as a factor influencing longevity may be connected with the influence of moisture on conidial germination. Numerous investigators have reported that fungus spores will germinate in the absence of free water. Katsura (1937) claimed that the conidia of *Helminthosporium oryzae* germinate at a relative humidity of 92 per cent but not at 89 per cent. In the present investigation, no germinating conidia were observed among those stored at 95 per cent relative humidity. At such a high humidity, however, the conidia must have approached germination. It would seem possible that some metabolic activities could progress under such conditions, and that the failure of the conidia to germinate after storage at high relative humidity may have been due to exhaustion of stored food reserves.

From these laboratory studies, it would appear that the conidia of *H. oryzae* are not likely to maintain their viability for long periods in the field. The warm, moist climates of many rice growing regions would be most unfavorable for the survival of conidia.

Since they failed to germinate after one month's storage at 95 per cent relative humidity at 31° C., and survived only three months at 24° C., it would be most unlikely that the conidia could survive through the winter under field conditions. The primary function of the conidia, then, would seem to be connected with the spread of the fungus rather than with its persistence.

SUMMARY

1. Low temperatures favored the retention of viability by the conidia of *Helminthosporium oryzae*.

2. In controlled temperature experiments in which the relative humidities during storage were controlled with sulfuric acid solutions, the conidia remained viable longer under cool dry conditions. At 20% relative humidity the conidia survived for six months with little loss of viability even when stored at 31° C., whereas at 95% relative humidity they failed to germinate after one month at 31° C.

CAMP DETRICK, MD.

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YEASTS IN DECOMPOSING FLESHY FUNGI

K. W. Anderson and C. E. Skinner

It has frequently been noted that yeasts are present in decomposing mushrooms but little knowledge of the identity of the yeasts is available. The present study is an attempt to supply information on this question.

Each species of mushroom (or other fungus) was placed immediately in a clean glass jar with a loose fitting screw-top cover as soon as it was gathered in the field. All of these were brought to the laboratory and unless the diagnosis of the fungi could be made in the field, duplicate samples were collected for later identification. Diagnoses were checked by the late Dr. A. T. Henrici. The jars were stored at laboratory temperature (about 25°–30° C.) and in two or three days, rarely longer, liquefaction had commenced. Tests for pH were made by the glass electrode at two or three day intervals. If an alcoholic fermentation became evident by an alcoholic or an esteric odor, attempts were made to isolate yeasts when such fermentation was most active. In case there was no such odor, attempts were made to isolate yeasts after liquefaction had proceeded two or three days. Glucose-tartaric acid-beef-peptone agar (3) was used for isolation. In cases where yeasts were not isolated, the fluid from the liquefied fungus was examined microscopically to verify the absence of yeast cells.

After the purity of the cultures was established, the yeasts were studied by the various biochemical and morphological methods outlined by Stelling-Dekker (4) and Lodder (2) in their monographs on sporogenous and asporogenous yeasts respectively. These same two works were also consulted to identify the yeasts. In most cases the identification was certain, but in a few cases there was a slight difference, usually in availability of nitrates or of rate of gelatin liquefaction. The differences were not in most cases such as to make us consider the possibility that we had new species. There was one *Saccharomyces* and one *Cryptococcus* that could not be placed in any species known to us, and isolations, apparently representing several species, from eight fungi that could not even be placed in a genus. It was finally decided that these were probably sporidia of smuts. Cultures were submitted to Dr. J. J. Christensen, who also thought that they were sporidia of smuts but he was unable to identify any of them.

The following table shows the kinds of yeasts isolated, the fungi from which they were obtained, the pH at the beginning of liquefaction, and the number of strains studied.

Occurrence of Yeasts in Decomposing Fleshy Fungi

Yeast	Fungus in which Yeast was Found	pH Beginning of Liquefaction	Number of Isolations
Saccharomyces cerevisiae Hansen (various varieties)	*Agaricus campestris*	8.2	2
	Armillaria mellea	3.6	1
	Coprinus micaceus	4.6, 4.41	9
	Coprinus ebulbosus	4.9, 4.7	6
	Coprinus comatus	6.0	1
	Hypholoma appendiculatum	4.41	6
	Lepiota Morgani	6.0	6
	Marasmius oreades	4.83	5
	Peziza odorata		2
	Phallus impudicus	3.7	1
	Russula emetica	4.5	6
Saccharomyces Chodati Steiner	*Lepiota naucina*	6.5	4
Saccharomyces dairensis Naganishi	*Armillaria mellea*	3.6	3
	Coprinus ebulbosus	4.9, 4.7	5
	Panus rudis	4.1	6
	Pluteus cervinus	5.21	6
Saccharomyces disporus Beijerinck	*Coprinus comatus*	6.0	1
	Coprinus micaceus		1
Saccharomyces heterogenicus Osterwalder	*Pholiota praecox*	5.21	4
Saccharomyces muciparis Beijerinck	*Peziza odorata*	7.0	4
	Tremella mesenterica	4.6	5
Saccharomyces sp.	*Mycena pura*	4.9	6
Cryptococcus pulcherrimus (Lindner) Benham	*Strobilomyces strobilaceus*	5.4	5
Cryptococcus utilis (Hennenburg) Anderson et Skinner*	*Strobilomyces strobilaceus*	5.4	1
Cryptococcus uvae Pollacci et Nannazzi	*Agaricus campestris*	8.2	1
	Coprinus micaceus	4.6	4

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* **Cryptococcus utilis** (Hennenburg) Anderson et Skinner, comb. nov. Syn.; *Torula utilis* Hennenburg; *Torulopsis utilis* Lodder.

OCCURRENCE OF YEASTS IN DECOMPOSING FLESHY FUNGI—*Continued*

Yeast	Fungus in which Yeast was Found	pH Beginning of Liquefaction	Number of Isolations
Cryptococcus sp. Except for the fact that no red color appeared, this is very like *Torulopsis pulcherrima* (Lindner) Sacc. var. *variabilis* Lodder	*Amanita muscaria*	4.54	7
	Armillaria mellea	3.6	1
	Coprinus micaceus	4.6	4
	Marasmius oreades	4.83	1
	Phallus impudicus	3.7	4
Rhodotorula colosteri (Castelli) Lodder	*Clavaria stricta*		5
	Pholiota praecox	5.21	1
Group 20—sporidia?	*Agaricus campestris*	8.2	2
	Amanita muscaria	4.7	6
	Amanita verna	7.8	4
	Boletus chrysenteron	6.85, 6.87	11
	Coprinus comatus	6.0	4
	Coprinus ebulbosus	4.7	8
	Coprinus micaceus	4.6	4
	Inocybe rimosa	6.3	6
Yeasts present, but not isolated	*Coprinus micaceus*	6.65	
	Tricholoma albellum	7.66	
	Boletus Satanas	5.15	
Not isolated and not seen in microscopic examination	*Coprinus atramentarius*	8.39	
	Agaricus arvensis	8.29	
	Calvatia gigantea	8.9	
	Polyporus betulinus	4.61	
	Marasmius oreades	8.6	
	Collybia radicata	7.62	
	Lycoperdon subincarnatum	8.24	
	Hypholoma incertum	7.95	
	Lycoperdon pyriforme	7.95	
	Daedalea confragosa	5.2	
	Calvatia cyathiformis	6.95	
	Russula alutacea	6.65	
	Amanitopsis vaginata	6.25	
	Lepiota Morgani	8.05	
	Clavaria aurea	6.3	
	Clavaria cristata	5.8	

There are several points in the table that might be commented on. The fact that such a large number of yeasts were isolated very readily from decomposing mushrooms indicates that we have in mushrooms an important habitat for these organisms which are probably carried thither by insects, many of which are known to harbor large numbers of yeasts. The chemical composition of several species of mushrooms has been determined (1, 5, 6). Many species have smaller or larger amounts of fermentable or utilizable monosaccharides. Considerable amounts of trehalose are also found in many mushrooms. Most yeasts are entirely unable to utilize or ferment trehalose. The hydrolysis to glucose must first be brought about by enzymes of the fungus itself, or of bacteria which are present with the yeasts. The presence of these carbohydrates thus makes the fleshy fungi a good medium for yeasts.

Secondly, it should be noted that a large percentage of the yeasts found formed ascospores. An unexpectedly small number of imperfect yeasts all belonging to the genus *Cryptococcus* or *Rhodotorula* were found, and none that could be identified as species of the common genus *Mycoderma.*

Another point of interest is the obvious connection between the presence of yeasts and low initial pH. pH determinations were made as soon as the fungi had liquefied sufficiently to obtain samples. In most cases low initial pH, an odor of alcohol or esters, and presence of yeasts went together. In nearly all cases where yeasts were not found, the odor was ammoniacal and the pH was high. It is probably not primarily the yeasts which make the medium acid since they are usually not strong acid producers; rather the yeasts became established in media made sufficiently acid by bacteria to prevent putrefactive bacteria from proliferating rapidly. This is a problem in pure ecology that should be worked out.

To verify the findings that yeasts usually are numerous only in decomposing mushrooms of high acidity the following additional work was done: Several samples of species of *Coprinus* were collected and allowed to decompose as described above. After liquefaction was well started pH determinations by colorimetric methods were made and yeasts were searched for by microscopic examination. Samples with the following pH yielded yeasts: pH 3.8, 4.0, 4.1, 4.3, 4.3, 4.6, 4.6, 4.6, 5.3, 5.6, 5.8, 6.0, 6.5, 7.6, 7.9, 8.1. The following failed to show yeasts: pH 6.8, 7.8, 8.2, 8.6, 8.9, 8.9. All except four of those with yeasts had a definite alcoholic or esteric odor, and all but one of those without yeasts had an ammoniacal odor. Thus the results of the former more carefully controlled experiments were confirmed: Yeasts will be expected to be found only in those samples of decomposing mushrooms which are acid.

Yeasts were isolated from only some of these samples, but from all in which an attempt was made to isolate them. The collection of perfect yeasts was lost, but the following additional imperfect species were identified: *Rhodotorula glutinis* (Fres.) Harrison, *Cryptococcus californicus* (Mrak et McClung) Anderson et Skinner [1] and *Cryptococcus spaericus* (Hammer et Cordes) Anderson et Skinner.[2]

SUMMARY

Yeasts were isolated from decomposing fungi, largely mushrooms, but also from some fleshy Ascomycetes. Samples of high pH rarely yielded yeasts, but those of low pH usually did so. The following yeasts were identified: *Saccharomyces cerevisiae, S. Chodati, S. dairensis, S. disporus, S. heterogenicus, S. muciparis, Cryptococcus californicus, C. pulcherrimus, C. spaericus, C. utilis, C. uvae, Rhodotorula colosteri, R. glutinis.*

DEPARTMENT OF BACTERIOLOGY AND IMMUNOLOGY,
UNIVERSITY OF MINNESOTA, MINNEAPOLIS, MINNESOTA

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[1] In order to retain the specific name *californicus* and to prevent the creation of another which would have to be considered valid, the following description is given with Dr. Mrak's approval:

Torulopsis californica Mrak et McClung: Cellulae sunt globosae in culturis maltatis liquidis, juvenes (usque ad 24 horas) 3.5–5.75 × 4.5–6.0 μ, seniores (3 diebus) 5.25–7.0 × 5.25–8.75 μ. Ascosporae non visae sunt. Dextrosum, laevulosum, mannosum, galactosum, maltosum, succrosumque fermentantur, neque autem lactosum nec raffinosum. Asparagin, sulfas ammoniae, urea, peptonumque leniter absorberi possunt, neque autem nitrates. Auctus est bonus in mediis in quibus spiritus frumenti fons carbonis solus est. Gelatinum non liquefitur. Habitat in culturis ex baccis *Vitis viniferae,* California. Descriptio extensior (*Torulopsis californicus*) lingua anglica facta est in *Jour. Bact.* **40**: 401, 1940. **Cryptococcus californicus** (Mrak et McClung) Anderson et Skinner, comb. nov. Syn. *Torulopsis californica* Mrak et McClung.

[2] **Cryptococcus spaericus** (Hammer et Cordes) Anderson et Skinner, comb. nov. Syn.: *Torula spaerica* Hammer et Cordes; *Torulopsis spaerica* Lodder.

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TYPE STUDIES ON BASIDIOMYCETES III *

ROLF SINGER

Most of the types reported on here are deposited in the Farlow Herbarium (FH), Harvard University. A few species were studied at the New York State Museum, Albany (NYS), or in the Herbarium of the Agricultural Experiment Station, University of Florida (FLAS).

FAM. RUSSULACEAE

LACTARIA TORMINOSA VAR. GLABRA Murr., Lloydia 6: 209. 1943. (Type.) LACTARIUS PSAMMICOLA A. H. Smith, Papers Mich. Acad. Sc., Arts, Letters 26: 62, pl. 1. 1941. (Type.)

Murrill says that *L. torminosus* "is exceedingly abundant" in Gainesville, and also describes the above-cited var. *glabra* of that species. We have carefully studied the type of this variety as well as the specimens determined as *L. torminosa* in the Gainesville Herbarium, and our conclusion is that none of them belongs to *L. torminosus.* This incorrect determination of the plant in question is not directly Murrill's fault. Murrill, in order to determine his *Lactarii* of Florida, relied on Coker's monograph of the species of South Carolina where the same species is likewise described under the name of *L. torminosus.* Actually, the species occurring so abundantly in the south, and much less commonly in the north of the United States, and corresponding to the characters indicated by Coker, had no valid name up to 1941. A. H. Smith seems to be the only one who clearly saw this situation, and, as a consequence, described this fungus as a new species, *L. psammicola,* the type of which I have seen at Ann Arbor, in 1941. Though it has been well described by its author (*l.c.*), our own description is based on innumerable collections and adds some chemical and anatomical data not given before:

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* Cf. Singer, R. Type studies on Basidiomycetes I–II. Mycologia 34: 64, 1942; 35: 134, 1943.

Pileus in early youth with "ochraceous orange" zones on "ochraceous buff" ground, later paler, *i.e.,* the zones "ochraceous buff," "cinnamon buff," "pinkish buff," "clay color" on a "pale pinkish buff" or "pale ochraceous buff" background, viscid, glutinous in the central half, slightly viscid in the marginal half, appressed tomentose or merely cobwebby-fibrillose or loosely woolly in the marginal half or third, increasingly so toward the very margin but in some individual fruitbodies sooner, in others later glabrescent from the middle outwards depending on habitat and weather, often with irregular ridges above the gills formed by the tomentum, with acute, involute margin that becomes straight in age, initially convex and deeply umbilicate, then the marginal quarter of the radius convex, the central part deeply infundibuliform, eventually often wholly concave, (55)100–185 mm. broad. *Lamellae* "cartridge buff," staining "fawn color" where they had been in prolonged contact with the droplets of the latex, subclose to crowded, forked, often forked-connate at the stipe, linear, narrow (3–7 mm. broad), arcuate-decurrent, or adnate-subdecurrent; spore print F (Crawshay's plate). *Stipe* white or whitish, the apex often with a more or less distinct "yellowish glaucous" band, in early youth in some specimens distinctly scrobiculate with spots concolorous with the pileus but later rarely and then sparsely scrobiculate, usually becoming smooth and unicolorous, the apex usually with a 2 mm. broad zone of longitudinal ridges continuing the lamellae, not discolored when handled, glabrous, firm, tapering downwards, (12)30–40 × 17–33 mm., considerably thinner below. *Context* pallid or concolorous with the surface though paler, rather firm but not rigid in the pileus and rather thick (5–9 mm.) there, slowly changing to "pale vinaceous fawn" and "pale Quaker drab," reaching "lavender gray" in the marginal third, the discoloration sometimes very indistinct and remaining unobserved if special attention is not paid to the color of the wounds after a time of 10 minutes from the moment of the bruising; latex not pure white, between "cartridge buff" and white, unchanging or concolorous with the injured portions of the tissue when left in contact with the latter for a prolonged time; odor agreeable, of apple; taste rather strongly acrid in a few seconds.

Spores 7.3–10(11.5) × (6)6.3–8(9.2) μ, asymmetrical, short-ellipsoid, hyaline, yellowish-hyaline in accumulations, coarsely warty on periphery, in iodine with long ridges (ornamentation of type I, more rarely II, never III) which project 0.9–1.3 μ and react strongly amyloid; *basidia* 40 × 9.5 μ, 4-spored; *pseudocystidia* 48–52 × 4–8 μ, fusoid, mostly with faintly banded contents but some always empty, with the bases proliferating to the trama, somewhat undulate-sinuose at times, attenuate upwards and subacute or narrowly obtuse; trama filamentous with many thin, (2.5–3 μ broad) laticiferous vessels; all hyphae without clamp connections; context with large laticiferous vessels running in all directions, hyaline; subcutis the same as the context but colored succineous-melleous and the hyphae (not the laticiferous vessels) running mostly parallel and horizontal; epicutis the same as the subcutis but less pigmented, the hyphae looser because of the gelatinous nature of the layer, the more scattered laticiferous vessels running parallel with the hyphae, and thinner than in the context; all laticiferous vessels bluing in sulphovanilline; dermatopseudocystidia none.

Methylparamidophenol strongly positive, reaching a deep lilac; **phenol,** strongly positive to "dusky brown" with "russet vinaceous" margins; **$FeSO_4$,** sordid; **H_2SO_4** and sulphovanilline, reddish black; **KOH,** weak reaction to slightly yellowish, the latex negative; **HCl, NH_3** and **NH_4OH,** negative or almost negative; **aniline** with lamellae somewhat slate gray after a while (vapors); context slowly salmon color then chocolate, then black (any of these phases may be wanting at times; use aniline oil).

Under oaks in high hammocks, in scrub areas, and on shaded lawns, generally on sandy soil in wooded areas with *Quercus,* gregarious, fruiting from May till October. From New England and the Middle West south to the Gulf of Mexico becoming more common southwards (same distribution as in *Russula albida* Peck, see below). Var. *glabra* Murr. is a form without taxonomic importance; the valid name for it, as well as for Coker's and Murrill's (Florida) *L. torminosus,* is *L. psammicola* A. H. Smith. The ornamentation of the spores and the chemical characters of the true *L. torminosus* of Europe and the northern states and Canada, are quite different.

RUSSULA DELICA Fr. sensu Bresadola, Fungi Trid. **2**: 88, pl. 201. 1900; Icon. 9, pl. 401. 1929. (Authentic material.) RUSSULA DELICA var. BRESADOLAE Sing., Bull. Soc. Myc. France **54**: 132. 1938. (Type.) RUSSULA BREVIPES Peck, Ann. Rep. N. Y. State Mus. **54**: 178. 1901. (Type and authentic material.)

The variety *Bresadolae* Sing. is based on the author's collections which were identified with *Russula delica* Fr. sensu Bresadola. J. Schäffer indicates that the latter is *R. pseudodelica* Lange. I have carefully compared the latter with my own specimens, and find the spores decidedly different. Schäffer's statement sounds puzzling if one examines a specimen collected and determined by Bresadola as *Russula delica* Fr. (September 1926, at Trento in oak woods), and distributed by J. Schäffer himself, with spores ornamented 1.5 μ high and more (*i.e.*, typical *delica*-spores), and the appearance and characters of the specimens exactly like those of *R. delica* var. *Bresadolae.*

We have also studied Peck's type of *R. brevipes* and material freshly collected at places where Peck's material of *R. brevipes* had been found. We could not discover any macro- or microscopical, or chemical difference between this and the European *R. delica* Fr. var. *glaucophylla* Quél. This coincides with the almost unanimous treatment this species has found in monographs. The writer finds the fresh spore print of most American collections either B, or between B and C (Crawshay).

RUSSULA SUBALBIDULA Murr., Mycologia 33: 441. 1941. (Type.)

The type of *R. anomala* Peck was reported on in a previous paper (Mycologia 35: 145. 1943), and recent collections in the northern part of the United States have shown that this species is not always as small as described by Peck, but also occurs in a medium sized form not otherwise distinguishable from the small type form. The type of *Russula subalbidula* is not distinguishable from this medium sized form of *R. anomala* Peck, except perhaps by being usually slightly less acrid. Since the writer has studied hundreds of fresh specimens of this species,[1] a complete description can now be given:

Pileus white or dull white with the disk frequently tinged pale buff to pale cream color, glabrous or sometimes slightly pruinate on the margin, unpolished, very slightly gelatinized during rainy weather, margin smooth, only in age short and irregularly sulcate, the margin forming an angle of about 90° (subacute) or obtuse from the beginning, always obtuse in age though not truly rounded, surface convex, the center soon broadly but usually not deeply depressed, the cuticle separable one sixth to one fourth of the radius from the margin, diameter 40–100 mm., rarely as small as 25 mm. *Lamellae* white, then cream color, close to subclose, attenuate-attingent to subdecurrent, eventually irregularly attached, not ventricose, rather narrow, more rarely rather broad, in average specimens 4–9 mm. broad, equal and simple, or if growth has been held back partially because of mechanical obstacles, a few shorter and forked ones are intermixed, low anastomoses present; spore print B (Crawshay), near " ivory yellow" (Ridgway). more yellow but not deeper colored than in Crawshay. *Stipe* white, initially subpruinose, glabrescent, slightly longitudinally rugulose, solid, then stuffed or hollow, slightly tapering upwards or downwards or subequal, 26–50 × (6)14–28(45) mm. *Context* white, unchanging, firm, eventually rather fragile; odor none or very slight of coconut; taste very slightly bitterish and acrid at the same time, the burning sensation of variable intensity, intensely acrid when young and fresh in some specimens but usually moderately, and eventually becoming subacrid to mild in old ones. *Spores* 10–10.5 × 8.5–8.8 μ when taken from a print, hyaline, echinate, ornamentation rather variable (most frequently of type VI, V, IV, also IIIb, rarely a few spores with type IIIa, or IV–II), 0.6–1.2 μ high, with the spines regularly or irregularly arranged, dense to sparse, mostly cylindric but also conic-obtuse; *pseudocystidia* 70 × 14–17 μ, some narrower, some shorter, but in an average rather voluminous, at least in the strongly acrid forms, clavate to fusoid, mostly bluntly rounded at apex, numerous, with banded contents, strongly and entirely bluing in sulphovanilline; basidia 37 × 6.5–7.5 μ, 4-spored; *epicutis* with numerous dermatopseudocystidia on the pileus and on the stipe (blue in sulphovanilline).

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[1] These are being distributed in Reliquiae Farlowianae, no. 992.

$FeSO_4$, somewhat inconstantly reacting, mostly grayish green on cuticle ("Andover green," "Lincoln green," "slate olive"), in one specimen merely grayish pallid; on lamellae pale grayish green or negative, never salmon colored anywhere. **Phenol,** chocolate (normal). **Formalin,** "light grayish vinaceous" to "vinaceous fawn" in 3–5 min. **Sulphoformol,** bright blue: "neropalin blue." **Sulphovanilline,** blue on fresh context. **Chloroformol** (40 per cent formaldehyde with concentrated HCl added), slowly bluish gray. **Nitroformol** (with concentrated HNO_3 added), somewhat blue after 6 minutes. **HNO_3,** dirty isabelline, eventually yellow on surface of pileus. **HCl** and **H_2SO_4** on pileus, negative. **Methylparamidophenol,** rather strongly positive. **Aniline** on lamellae slightly dull red with a pale melleous margin, almost negative.

In mixed and oak woods, high hammocks and on shaded lawns under oaks, solitary to very gregarious; fruiting from May until July, probably also later. Eastern United States.

Material studied: **N.Y.** Type of *R. anomala* (NYS). **Fla.** In and around Gainesville, Alachua Co., common in early summer, *R. Singer,* F1971a, F1971b (FH). Type of *R. subalbidula* Murr.

(FLAS); also authentic material (FLAS) and fresh material of the writer authenticated by Murrill (FH). **Mich.** Waterloo, singly under oak and juniper, July 20, 1942, *W. B. Gruber* (A. H. Smith 18520), det. R. Singer (MICH, FH). **Ala.** Alabama Biological Survey, Dadeville, Aug. 28, 1897, *C. F. Baker* (Burt Herb., FH); other collections from Alabama (*Earle*) in the herbaria (NY, NYS) are not, as they were determined, *R. albella,* but *R. anomala* (*R. subalbidula*).

Earle determined and published his Alabama specimens under the name *albella* before Peck had published the Long Island collection of *R. albella,* but they are different. Since Earle's *R. albella* is a *nomen nudum,* we recognize Peck's type at Albany as valid. This has occasional red hues, reticulate spores and more scattered dermatocystidia, and may possibly be an albino form of some normally reddish species of the section Rigidae.

R. anomala belongs in the section *Ingratae,* subsection *Felleinae.* It is related to *R. fellea* Fr. (*R. simillima* Peck[2]), *R. innocua* Sing. (*R. albida* Peck sensu Kauffm. p.p. *non Peck sensu originali*), etc. It is remarkable for its reactions. Specimens preserved in the preserving fluid "vasco" also become blue as has been pointed out by Murrill. The blue reaction with sulphoformol was previously known only from one European species, *R. rosea* Quél. (*R. aurora* Krombh. *sensu* Melzer & Zvára *non* Bres.) sensu R. Maire (1910) *non* Singer (1926), and its smaller variety, *R. rosea* var. **minutula** (Velen.) Sing. comb. nov. = *R. minutula* Velen. = *R. uncialis* Peck *sensu* Melzer & Zvára *non sensu originali.* In this species, the sulphoformol reaction is accompanied by a parallel bright red sulphovanilline reaction whereas, in *R. anomala,* the sulphovanilline reaction is not bright red. *R. anomala* is not related to *R. rosea.*

Considering the fact that the northern *R. anomala* was very little known and its macroscopical description not fully suggestive of the medium sized moderately acrid form commonly found in Florida, it is understandable that Murrill redescribed it under a new name. This latter—though better supported by a recognizable description and a larger number of specimens than Peck's species—must nevertheless be considered as a synonym of *R. anomala* Peck.

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[2] *R. simillima,* as collected fresh in the Adirondacks, N. Y., is only a form or race of *R. fellea* Fr.

RUSSULA MACULOSA Murr., Lloydia 6: 212. 1943 (Type and fresh material from type locality, compared with the type).

Pileus white with sordid or rusty brownish spots or patches, or a very pale Isabella color (not in Ridgway) on the cracked surface, usually center and patches "chamois," otherwise pallid white, opaque, dry or slightly viscid, with acute or subacute margin which becomes more obtuse in age but never rounded, smooth then usually short to long sulcate or striate, surface convex then flattened and depressed, sometimes umbilicate, eventually concave, initially with broadly incurved margin, diameter 40–105 mm. *Lamellae* white, becoming pale cream color, unchanging or slightly staining brownish where injured, crowded to subclose, plane, equal or with very short lamellulae on the margin, some or usually many forked, especially near the stipe (bifurcate-connate), narrow, with entire edge, not or scarcely anastomosing, narrowly adnexed to subdecurrent, sometimes somewhat separating from the apex of the stipe; spore print from between A and B to B (Crawshay). *Stipe* white, at times with rusty or alutaceous spots, or slowly becoming so when injured, glabrous or subglabrous, solid, later stuffed, slightly tapering downwards or upwards, or ventricose, or more rarely subequal, 30–60 × 10–30 mm. *Context* white, rarely slightly pale brownish alutaceous after long exposure, usually unchanging, thin to medium thick but firm-elastic in the pileus; odor none, or eventually (often on drying) becoming disagreeable, of sweat (as in *R. parazurea*), or chloride of lime (as in certain Amanitas); taste mild in all stages.

Spores (5.8)6.5–8.7 × (4.2)5.3–7 μ, mostly 7.5–8.2 × 6.2–6.5 μ, short-ellipsoid to subglobose, slightly rough, ornamentation (0.1) 0.2–(0.5) μ high, of type (IIIa), IIIb, IV, V, (VI), IIIb–VIII, IIIb–VII, with one small round oil droplet; *basidia* 27–54 × 8–10.5 μ, mostly 38–44 × 8.7–9.2 μ, clavate, 4-spored; pseudocystidia 37–75 × 6.2–11.5 μ, most frequently 65–75 × 7.2–11 μ, cylindric or fusoid, rarely capitate, sometimes fusoid-clavate, not appendiculate, or rarely some short appendages present, usually moderately numerous, a majority with at least an apical internal body bluing in sulphovanilline, many with banded contents in some part, few with evenly scattered contents obtuse or subacute, sometimes with a subcylindric bottle-neck apex; *cheilocystidia* not differentiated; edge homomorphous; *subhymenium* a rather thin subcellular layer; *trama* with large and numerous spherocysts and large filamentous areas; *surface of stipe* with subfasciculate hyphal ends cylindric-capitate, 3.5–4.3 μ in diameter; *epicutis* of pileus consisting of cellular chains (cells 10–18 × 7–15 μ), sometimes the upper members becoming increasingly narrowed as they approach the tip of the chain, the terminal member usually hair-like, often bottle shaped, occasionally clavate (*e.g.* 22 × 9 μ), or cylindric (20 × 4.5 μ); there are also some hyphal ends reaching the epicutis, and some of them are incrusted (primordial hyphae); *subcutis* made up of somewhat interwoven, repent hyphae which are long-filamentous, 2.5–4.5 μ in diameter, hyaline, smooth, and clampless.

$FeSO_4$, everywhere constantly salmon color. **Methylparamidophenol,** strongly positive. **Sulphovanilline,** on dried surface of stipe "garnet brown" (deep red). **Chlorovanilline,** negative everywhere.

Under frondose trees, mostly oaks, preferably *Quercus virginiana* and *Q. laurifolia* in Florida, on the ground, solitary or gregarious; fruiting from May until October. From the Carolinas south to North Florida and west to Tennessee and Alabama.

The above is an emended description of the plant called *R. chlorinosma* Burl. in Bull. Soc. Myc. Fr. **55**: 242. 1939, and at the same time of *R. maculosa* Murr. The latter is a synonym of the former unless—quite unexpectedly—the type of *R. chlorinosma* should turn out to be specifically different from the form described above.

This species is easily distinguished from *R. crustosa* Peck (the closest relative), by the color if observed unbleached in both cases, also by the slightly acrid taste of *R. crustosa* when young. We have observed another species in Florida that belongs in the same stirps. It closely resembles *R. chlorinosma* (*R. maculosa*) but has more narrowly ellipsoid spores. This shape is not within the limits of variation of *R. chlorinosma,* but rather reminds one of that of *R. heterospora* Beardslee. It is remarkable that the North and Central Floridan agaric flora is so rich in narrow spored species in groups where short spored species are the rule, and this not only in *Russula* but also in *Amanita,* and most striking, in *Hygrophorus* (such as *H. russuliformis, H. subsordidus* Murr.).

RUSSULA ALBIDULIFORMIS Murr., Lloydia **6**: 209. 1943. (Type.)

Pileus white to whitish, more moist than viscid when wet, glabrous, convex, then more or less depressed, fleshy, with incurved, then acute, smooth, but eventually striate margin, with a cuticle that scarcely peels for any distance from the margin, diameter 60–80 mm. *Lamellae* white, then pale orange, adnexed, often separating from the stipe, comparatively thick, many forked, especially near the stipe, or at half-height, equal, close to subclose, moderately broad; spore print somewhat more salmon colored than B of Crawshay's plate ("pale pinkish cinnamon"). *Stipe* white, smooth, solid or somewhat stuffed, usually subequal, 50 × 12–16 mm. *Context* white, unchanging, rather hard; taste mild; odor none, eventually agreeable like that of apples.

Spores 7–9.8 × 5–6.5 μ, slightly rough to subsmooth, hyaline, ornamentation up to 0.2 μ high, of type VII, or VI, V, IV, III, mostly consisting of crossing lines forming small warts at the nodes, about as figured for *R. melliolens* by R. Maire (1910); *basidia* 37–48 × 8.8–11.2 μ, 4-spored, either the short or the elongated type prevalent; *cystidia* 53–75 × 5–10.2 μ, wavy, fusoid, or subulate, or ampullaceous, rather characteristic in appearance, sometimes with 1–3 basal septa (the lower divisions not a part of the subhymenium), inside empty in all parts, or finely granulose partly or entirely, without, however, any banded contents; *cheilocystidia* none; edge homomorphous; *subhymenium* consisting of small cells, not filamentous at all; *trama* of large spherocysts, with many connective hyphae intermixed among them; *epicutis* made up of hair-like dermatocystidia (not of the pseudocystidia-type), these are subulate and do not turn blue in sulphovanilline, empty or with the same kind of contents as observed in the hymenial cystidia, hyaline, very crowded; all hyphae without clamp connections.

$FeSO_4$, negative. **Formalin**, negative.

Under and near oaks in high oak woods and in the scrub (not in very dense hammocks), on sandy soil, solitary or in small groups; rare; fruiting from September until October. Through Florida, excepting the tropical zone.

Material studied: **Fla.** Highlands Co., scrub section of the Botanical Garden, Highlands Hammock State Park, *R. Singer, F571;* Alachua Co. **Type** (*E. West* & *W. A. Murrill, F9561*).

A species easily recognized by its spores. It may be considered as belonging to the *Elephantinae* or *Chlorinae* (like *R. elephantina* = *R. mustelina*). The negative reaction with $FeSO_4$ and the color of the spores are distinctive in any section or subsection in which it may be placed.

RUSSULA ALBIDA Peck, Bull. N. Y. State Mus. 1 (2): 10. 1888. (Type.)

R. albida Peck has been studied previously, but the specimens were from the Kauffman Herbarium (MICH), and represent part of a collective species, *R. albida* Peck *sensu* Kauffman, containing the following elements: (1) *R. albida* Peck *sensu originali,* corresponding to the type at Albany; (2) a mild form, probably identical with *R. innocua* Sing.; (3) a somewhat acrid form, *R. anomala* Peck. My previous notes refer to this third element. As for the original *R. albida,* it may be said that it is also the one so identified by Beardslee, by Murrill, and others. The type specimens still show a distinct reaction with sulphovanilline and chlorovanilline very similar to that of *R. rosea* Quél. (*R. aurora sensu* Melz. & Zvára[3] and its smaller variety). The white pileus and the cream colored spore print in addition to the bitter taste make this the most unmistakable *Russula* known to me. The following revised description of the typical *R. albida* Peck is drawn from fresh specimens compared with the type.

Pileus white or whitish with the center sometimes tending to be pale cream colored, sometimes with brownish or ferruginous brown spots or specks, dry, rarely subviscid after prolonged rains, subglabrous to subvelutinous or like kid, convex, then with depressed center, with obtusely rounded margin which is smooth but eventually short (up to 3 mm.), sulcate in many specimens, the cuticle separable over one third to one half of the radius, diameter 25–60(110) mm. *Lamellae* white then cremeous, crowded or close, equal or nearly so, some bifurcate at the stipe, otherwise simple, broadest in the outer third (2–6, rarely up to 8 mm. broad), adnato-decurrent or somewhat decurrent; spore print B to C (Crawshay). *Stipe* white, dry, subglabrous, tapering downwards, or upwards, or ventricose, also often nearly equal, smooth, stuffed, then hollow, 25–90 × 7–11 mm., more rarely thicker, and up to 16 mm. broad. *Context* white, rather firm but not hard, unchanging; taste mild with a more or less (sometimes hardly noticeable) bitterish after-taste, always bitter in the cuticle; odor none.

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[3] Schäffer was right in identifying *R. aurora* Krombh. *sensu* Bres. with *R. lepida* Fr. rather than with *R. rosea* Quél. An authentic specimen received by Burt from Bresadola (FH) reacts with sulphovanilline and chlorovanilline in about the same way as *R. Zvarae, i.e.,* normally; the epicutis shows some rather narrow dermatocystidia.

Spores 8.8–10.8 × 7.8–9.2 μ, mostly 10 × 8.7 μ, yellowish hyaline, with dense, coarse, cylindric spines, connected by fine lines that do not form a complete network (type IIIb, IV), more rarely isolated (V, VI), very rarely with short ridges (IIIb–II, IV–II), projecting 0.6–1.0 μ; *basidia* 34–38 × 10.8–13 μ, broadly clavate, 4-spored; *cystidia* rather numerous on edge and sides of gills, 62–82 × (6.7) 10–14 μ, fusoid-ventricose, or fusoid with the thickest portion either near the middle or in the upper third or quarter, acute, usually short-appendiculate, with a fine granulosity (not banded) inside, not bluing in sulphovanillin; *primordial hyphae* on pileus and stipe present; surface of pileus with felty-interlaced, hyaline (in the brown spots brownish) hyphae with somewhat thickened walls (0.7 μ) and narrowly clavate ends (4–6 μ in diameter); *dermatopseudocystidia* none on pileus; all hyphae without clamp connections.

$FeSO_4$, on flesh of stipe normal (grayish-reddish). **Phenol,** slowly to "vinaceous purple," then "taupe brown." **Phenol-aniline,** red. **KOH,** on cuticle yellowish; otherwise negative. **Sulphovanilline,** "spectrum red," then "carmine." **Chlorovanilline,** with dried context between "spectrum red" and "carmine" or more purely "spectrum red" for a short while, then slowly, through "Eugenia red" and "Amaranth purple," reaching ' Indian lake."

Solitary or in groups in hammocks (high, mesophytic, low, and tropical), mixed woods, also in almost pure pine woods, either with pine (*P. australis*, or *P. palustris*, etc.), or with oak, either on the ground, especially on banks and in ditches, or on dead or living trunks, especially of *Sabal palmetto* sometimes several feet above the ground; fruiting from June until October. From New England to Florida (including the tropical zone), and west to Michigan and Alabama, perhaps farther west (western limits not established), increasingly frequent towards the south.

Material studied: **N.Y.** Sandlake. Type (NYS). **Pa.** Trexlertown, *Herbst* (FH). **N.C.** Asheville, *Beardslee* (FH). **Fla.** Fresh material from Dade, Highlands, and Alachua Co., *Singer* (FH); dried material seen from Alachua, Marion, and Levy Co., det. Murrill (FLAS).

This belongs to the *R. rosea* group of the subsection *Lepidinae* of the *Rigidae* Fr. I do not believe that *R. aurora* var. *cretacea* Melz. & Zvára, a bleached form of *R. rosea* in my opinion, is identical with *R. albida.* The latter never shows the slightest trace of red, and can by no means be considered as a white form of *R. rosea.*

RUSSULA RUBESCENS Beardslee, Mycologia 6: 91. 1914. (Type, and several fresh collections.) RUSSULA OBSCURA (Rom.) *sensu* Kauffman, Agar. Mich. 1: 148. 1918. (Authentic material.) RUSSULA KAUFFMANIANA Sing., Bull. Soc. Myc. Fr. 55: 258. 1939 (publ. 1940).

The strong influence Kauffman's concepts exercised on the opinions of those working on *Russula,* is due to the fact that he had, in general, a more concrete instead of abstract idea of the species, and his specimens are the ones most frequently exchanged and commented on. Considering the difficulty of this genus, and the enormous number of species occurring in Temperate North America, it is gratifying to see that Kauffman often, probably in a majority of cases, had the same concept about the species as expressed in the types. *R. rubescens* and *R. obscura* belong to that minority where Kauffman erred. In fact, *R obscura sensu* Kauffman is so different from the European *R. obscura* = *R. vinosa* that the writer described it as a new species, *R. Kauffmaniana,* based on the authentic specimens from the Kauffman Herbarium (MICH, LE) of *R. obscura sensu* Kauffman. This was done under the presumption that *R. rubescens* Beardsl. is nothing but *R. vinosa* in the European sense. However, the type of *R. rubescens* reveals that it is the same as *R. Kauffmaniana,* and fresh material collected in New England as well as in the south by the writer has added the evidence, thus far lacking, needed for a full description of this common American representative of the *Decolorantinae.*

Pileus "Corinthian pink," "Corinthian red," "light Corinthian red," sometimes with some pale greenish ocher or chamois intermixed or partially bleached, sometimes much darker on the disc, subglabrous, subviscid when wet, sometimes partly subpruinose or very minutely subrimulose, with a smooth, or in age short-sulcate, subobtuse or obtuse margin, with the cuticle peeling moderately well except on the disc, opaque in fresh condition and sometimes shining in dried condition, convex with depressed center, eventually concave, 34–70(85) mm. *Lamellae* stramineous-ochraceous, rather broad (6–8 mm. broad), close, attingent-subfree, equal, simple, but mostly connately-bifurcate at the stipe; spore print G (Crawshay). *Stipe* white, rarely with a reddish hue, becoming grayish (with "deep mouse gray" elevations on white ground), subrugulose, moderately firm, eventually very fragile, subequal, or tapering upwards with somewhat widened apex, stuffed, 30–50 × 6.5–15 mm. *Context* white, normally reddening before becoming dark gray, or immediately becoming gray stained, or entirely gray, becoming gray also in age and often on drying; taste mild; odor slightly fruity and at the same time of Camembert cheese.

Spores 8.8–11 × 7.5–9.5 μ, mostly 9.5–10 × 8.5 μ, short-ellipsoid to subglobose, yellowish, warty, ornamentation projecting 0.7–1.6 μ, consisting of cylindric spines, type VI, fewer IV, IIIb, IIIb–II, or IIIb–VIII, the connecting lines usually very fine; *basidia* 35–42 × 9–11 μ, clavate, more rarely tapering upwards from the thickest portion in the upper quarter, 4-spored; *pseudocystidia* 60–85 × 7–11 μ, fusoid, with the broadest portion at or more often above the middle and the tip acute, more rarely clavate, with yellowish banded contents, numerous on the sides and very numerous on the edges of the gills, bluing almost entirely in sulphovanilline; subhymenium of irregular, small elements, subcellular; *epicutis* of pileus made up of numerous, rather stiff and usually very straight dermatopseudocystidia of 30–90 × (4)6–8 μ, fusoid or more often clavate, their contents yellowish or hyaline, bluing in sulphovanilline; *subcutis* persistently pink in the purple portions of the pileus in NH_4OH offering a characteristic background for the usually yellowish dermatopseudocystidia.

Formalin with context, red.

Most frequently in low mixed woods near oaks, even in low hammocks, solitary or in small groups, from July until September. From New England south to Florida, and west to Michigan and probably Alabama and Tennessee.

Material studied: **Mass.** Arlington, *Singer* (FH); Wakefield, *Singer* (FH). **N.C.** Part of type (NY). **Fla.** Kelley's Hammock, Alachua Co., *Singer F2718* (FH). **Mich.** Authentic material of *R. obscura sensu* Kauffman (MICH).

This species is easily distinguished from *R. vinosa* by the ratio between the length of the spines of the spores and the diameter of the spores without ornamentation, also by the characteristic structure of the epicutis, the habitat, and the smaller size, to a certain degree also by the color.

RUSSULA CONGOANA Pat., Bull. Soc. Myc. Fr. **30**: 336. 1914. (Type.)

The type specimen from Kaga M'bra, French Congo, coll. M. Baudon, June 6, 1912, No. 1666, is colored like the red form of *R. Mariae* Peck; its pigment on the pileus and stipe is dissolved. The spores are 8.5–11.5 × 7.5–9.5 μ, asymmetrical, with 0.7–1.1 μ high ornamentation of type II, or II–IIIa; in the hymenium of the lamellae, there are numerous broadly clavate pseudocystidia with yellow amorphous contents (and it might be that these are the cause for the yellow color of the lamellae; the spores are not strongly pigmented, yet, when carefully compared with those of *R. emetica,* they appear slightly yellower), 39–70 × 12–14 μ; pileus with rather numerous dermatopseudocystidia, filled with banded contents, 39–41 × 7.5–8.8 μ. The lamellae are pale yellow as perhaps in dried *R. integra* = *R. Velenovskyi;* a spore print was not obtained by the collector, and it can only be estimated (B, C, or D); the margin is not distinctly acute, probably obtuse, slightly sulcate but neither pectinate nor grooved-plicate. This appears to be a representative of the section *Constantes,* probably belonging to one of the following subsections: *Emeticinae, Sardoninae,* or *Integrinae* (as used in my monograph). It would be desirable to learn about the taste of this species which according to the microscopical characters one would expect to be acrid.

RUSSULA ABIETINA Peck, Ann. Rep. N.Y. State Mus. **54**: 180. 1901. (Type.)

The type collection of *Russula abietina* as preserved in Albany consists of several specimens in good condition. These specimens are not all the same thing, and no particular fruiting body has been designated as the type specimen.

One element of the type collection is a species with spore ornamentation of type IIIa, more rarely IIIb which is only 0.5–0.7 μ high on an average while occasional larger spines do occur; in this form the general measurements of the spores are 7.5–9 × 5.7–7.2 μ.

This part of the type is macro- and microscopically identical with *R. Blackfordiae* Peck which we have shown to be the same as *R. serotina* Quél. *sensu* Melzer & Zvára, or *R. versicolor* J. Schäffer.

The other part of the type collection has larger spores (9.3–11 × 8.5–9.2 μ) with higher (1.0–1.4 μ) ornamentation which is less reticulate and more variable, most frequently belonging to type IV, or V–VI, or IIIb, sometimes showing catenulate lines (VIII). This part of the type collection is macro- and microscopically identical with the white-stemmed form of *R. sphagnophila,* described as var. *subingrata* on the basis of Czechoslovakian specimens by this writer in 1931. It was also found (authentic specimens at the Farlow Herbarium) in the Adirondack Mts., N.Y., by the writer in 1941, immediately recognized as *R. sphagnophila* Kauffman (by the way, also the red stemmed form was found there, and it had the same spore size as found in Europe), and it occurred invariably near birches. In most balsam fir woods of this mountain district here as well as in New England, various species of *Betula* may be mixed in. This is the explanation of the otherwise puzzling indication of the habitat by Peck. As in Europe, var. *subingrata* has slightly more frequently connected warts on the spores than the type variety, and the taste varies from entirely mild to very slightly acrid in youth, especially in the lamellae. It is, nevertheless, not always quite clearly separated from the type variety, yet it is different enough to puzzle and mislead good specialists of the genus like Peck, Burlingham, Kauffman who even put the type and the variety in different sections.

The type collection, being a mixed collection, *R. abietina* becomes a *nomen ambiguum* and has to be abandoned in favor of *R. Blackfordiae* Peck and *R. sphagnophila* Kauffm.

R. Maire has reported this species from Europe, and the writer has reported it from the Pacific Coast. If Maire's concept of *R. abietina* is that of Peck, *i.e.,* a sum of *R. Blackfordiae* and *R. sphagnophila,* the fact of its occurrence in Europe would not be surprising since both these species are known to occur there. However, Maire's remarks on his *R. abietina* (habitat under *Pinus* and *Picea;* comparison with *R. nauseosa* and *R. puellaris;* also the fact that Maire indicates *R. versicolor* = *R. Blackfordiae* and *R. venosa* = *R. sphagnophila* at the same time and as different species) would rather lead to the conclusion that *R. abietina sensu* R. Maire *non* Peck is the same as *R. nauseosa* (Pers. *ex* Fr.) Fr. as understood by most European authors including this writer.

My *R. abietina* Peck *sensu* Singer *non* Peck, Bull. Soc. Myc. Fr. **54**: 157. 1938 is also not the combination of forms so named by Peck but an autonomous species occurring only in the Pacific Coast States, the correct name of which may be *R. placita* Burl. What I described as *R. Turci* in Europe (1926, 1932) and identified with *R. abietina sensu* Sing. *non* Peck in 1938, is extremely similar to the latter, yet, as more material (from E. E. Morse and from A. H. Smith, with more specimens, notes, and a color stereophotograph) shows, cannot be considered as conspecific with it. It appears that *R. Turci* Bres. is represented in the herbaria by numerous collections which seem to belong to different species, and have been interpreted differently in the literature though the earlier interpretation (Maire, J. Schäffer) has not been recognized by Bresadola. We now consider *R. Turci* Bres. as another *nomen ambiguum,* and propose the new name **Russula neglecta** Sing. nom. nov. (*R. Turci* Bresadola *sensu* Sing. *non* Maire *nec* J. Schäffer) for our interpretation, with the type being the collection sent by Bresadola to New York Botanical Garden (see Mycologia **34**: 91. 1942). I suspect that this species is hiding in what J. Schäffer now calls "Das Problem *R. chamaeleontina* Fr." (Ark. f. Bot. **29A**: 39–42. 1939). It may well be that the pseudodermatocystidia of the pileus are inconstant (they are certainly not too abundant in my specimens), and accompanied by primordial hyphae. This, if true, would explain my own share of error in the history of *R. neglecta.*

RUSSULA MURRILLII Burl., Mycologia **5**: 310. 1913. (Supplementary data on type.)

Though I cannot discover any anatomical or external difference between this and the European-Asiatic *R. punctata* Krombh. *sensu* Sing. = *R. amethystina* Quél. *sensu* J. Schäff., excepting the spore color, I feel my conclusion on the type specimen (Mycologia **34**: 77. 1942) is misleading and needs to be modified. In spite of the fact that the type, as a specimen, has all visible characters in common with *R. punctata,* and seems to be identical with specimens of the latter, it may nevertheless be a subspecies or a closely related species. Newly arrived material which I owe to Dr. Alexander H. Smith was accompanied with a good color stereophotograph and thick spore prints. The fresh fruitbodies look entirely like *R. punctata* but the spore print is from C–D to D–E (Crawshay) and near "warm buff" of Ridgway in tone, thus definitely lighter colored than the spore print of *R. punctata.* This difference can hardly be explained by variability, and even so, such variability in one region would at least suggest a subspecies; if any character—perhaps chemical—could be discovered that is constantly correlated with lighter colored spores, *R. Murrillii* might very well be considered as autonomous.

RHODOGONIOSPORACEAE

CLAUDOPUS CYANEUS Murr., Mycologia 35: 429. 1943. (Type; also fresh material compared with it.)

Pileus between "Indigo blue" and "dusky blue," smooth, subtomentose-subfibrillose, especially near the zone of attachment, dimidiate, from 6 mm. (up to 20 mm. according to Murrill) in diameter. *Lamellae* paler blue, soon with pink spore dust, subdistant to distant, rather broad (up to 2 mm. in medium sized specimens). *Stipe* concolorous, subglabrous, very eccentric, sublateral, 2–3 × 1–1.5 mm. *Context* pallid, very thin; taste farinaceous but not bitter; odor farinaceous.

Spores 8–10.7 × 5.5–7 μ with (5)–6 angles or nodules, with suprahilar depression, the lower end in frontal view rectangular (symmetric type of Romagnesi); *basidia* 40 × 10 μ

Our own collection was on wood of *Ostrya virginiana* in a mesophytic hammock southwest of Gainesville, Fla., July 1, 1943 (F 2480).

The new combination **Rhodophyllus cyaneus** (Murr.) Sing. comb. nov. is proposed for this species. It belongs in what I have called the subgenus *Eccilia* of *Rhodophyllus* which also contains the other small, pleurotoid species such as *R. depluens* (Batsch *ex* Fr.) Quél. (also common in Florida, even on tropical hosts such as *Ficus aurea,* etc.), and *R. byssisedus* (Pers. *ex* Fr.) Quél.

Entoloma cyaneum Peck, a very striking species that also belongs in the genus *Rhodophyllus,* was first described by Peck as *Agaricus cyaneus* Peck *non* Persoon *nec* Secretan. It is a homonym and should be called **Rhodophyllus violaceus** (Murr.) Sing. comb. nov.

SCUTIGERACEAE

DIACANTHODES PHILIPPINENSIS (Pat.) Sing. Lloydia **8**: 141. 1945. (Type, as *Daedalea.*) ABORTIPORUS SUBABORTIVUS Murr., Bull. Torr. Bot. Club **65**: 655. 1938. (Type.)

Pileus light fulvous to fulvous brown, slightly to strongly coarsely rugose to toothed by spines, sometimes with concentrically arranged rugosities or obtuse elevations, not zonate in the manner of the *Corioli,* subglabrous, with more or less broadly sterile margin, context soft but not actually fleshy, consisting of a comparatively thin upper layer that is loosely felty, the thicker, lower layer more compact, more white and often separated from the upper layer by darker cartilaginous lines in dried material; odor none, taste mild; diameter of the pileus up to 150 mm. *Pores* white, small (0.5 mm. broad or even narrower) but rather angular, unchanging; tubes with thin, tender walls, 1.5–3 mm. long, decurrent, edges even, later denticulate. *Stipe* concolorous-paler, eventually a deep cinnamon color, subglabrous or glabrous, smooth or somewhat rough, eventually polished, subequal or irregular, with a pseudorrhizal proliferation (crypts) on the substratum, 45–90 × 12–45 mm.

Spores 6.5–8.8 × 5.5–7 μ, with cylindric, thin, non-amyloid 0.7–1.4 μ long spines, walls thin, non-amyloid but occasionally very slightly pseudoamyloid (?), yellowish-hyaline in KOH, with or without an indistinct hyaline perisporium that sometimes covers the lower half or all of the spines, subglobose, always abundant; the hilar appendage asymmetrically attached; in print white or whitish; *basidia* 15–32 × 8–8.5 μ, short and thick, clavate, often with very strange hook-like excrescences on the side of the apex; *cystidia* none, but deformed sterile basidia (pseudoparaphyses) scattered, 20–30 × 7.8–8.2 μ, frequently fusoid with obtuse apices; hyphae of the *subhymenium* with very crowded septa, short-cylindric; *hyphae* of the hymenophoral trama thick-walled to thin-walled (toward the terminal members of hyphae-chains thinner-walled), non-amyloid; clamp connections numerous.

The above description is based on our own collections from the Matheson Hammock, Dade Co., Fla. (F 757) where it grew in a tropical hammock on the ground above lime rock but the mycelium was visibly connected with the roots of *Bursera simaruba.* It is therefore not surprising to find the habitat of *D. philippinensis,* type, indicated as rotten wood. The colors, the appearance, size and pore characters, the quality of the surfaces, and also all the microscopical characters are virtually identical in my Florida specimen, in Murrill's and in Patouillard's type, and also in a Brazilian collection.[4] The genus *Diacanthodes* is intermediate between *Bondarzewia*[5] and *Abortiporus.*[6]

FARLOW HERBARIUM,
HARVARD UNIVERSITY,
CAMBRIDGE, MASS.

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[4] Murrill, defending his species (Mycologia 37: 793. 1945), says that in *D. philippinensis,* the color and zonation of the pileus are different, the stipe longer and varnished, and the spores larger and echinulate instead of minutely rough as indicated by Murrill. Patouillard described his specimen from the dried condition, and his description "cremeo dein fuscentente" (not cream to fuscous) and "azono" is not too far off, at least for many of our specimens. The same is true for the size and surface of the stipe. As for the spores, I found them up to 8.5 × 7.5 μ in Murrill's type and the spines exactly as described above. Murrill's measurements are too low (under an oil immersion lens, the ornamentation included) at least for mature spores. The fact that a species described from Florida falls in synonymy with a little known species from the Philippines does not reflect in any way upon the author of the synonym. These things are bound to happen from time to time, and we should keep in mind that the establishment of the synonymy in type studies is an important help to future taxonomists because it simplifies their task.

[5] *B. montana* (Quél.) Sing.; *B. Berkeleyi* (Fr.) Bond. & Sing.

[6] *A. distortus* (Schw.) Murr.; *A. borealis* (Vahl *ex* Fr.) Sing.; *A. humilis* (Peck) Sing.; *A. Peckianus* (Cooke) Sing. (*Polyporus Peckianus* Cke.); *A. dealbatus* (Berk. & Curt.) Sing. (*Polyporus dealbatus* B. & C.).

A NEW SPECIES OF CONIOTHYRIUM PARASITIC ON SCLEROTIA

W. A. CAMPBELL[1]

(WITH 1 FIGURE)

In the investigation of Sclerotinia disease of guayule in a plantation near Salinas, California, isolations were made either from diseased root tissue or associated sclerotia from approximately 200 infected plants. Pure cultures of either *Sclerotinia minor* Jagger or *S. sclerotiorum* (Lib.) D. By. were obtained from the majority of these infected plants. However, in two instances the sclerotia of *S. sclerotiorum* produced in Petri dish cultures became covered with the pycnidia of a contaminating fungus after three to four weeks at room temperature. Pycnidia were confined to the sclerotia and did not develop on the mycelial mat. The contaminating fungus was readily obtained in pure culture and was identified as a species of *Coniothyrium*. Preliminary inoculation experiments wherein pycnidiospores were placed on sclerotia of *S. sclerotiorum* demonstrated that the fungus was parasitic. The biological control of one fungus by another is always an interesting possibility; therefore, further inoculation experiments as well as studies on the cultural and morphological characters of the fungus were conducted.

In January, 1946, a collection of sclerotia of *Sclerotinia sclerotiorum* was made from diseased Brussels sprouts. These sclerotia and others produced on sterile oats were buried in sterile sand and maintained under suitable moisture and temperature conditions for apothecial formation. Twenty-five sclerotia from Brussels sprouts were buried in one-half of each wooden flat and twenty-five sclerotia from sterile oats in the other half. After approximately three months apothecial development had ceased and the sclerotia were recovered from the fifteen flats by washing the sand through a fine screen. Two hundred and eighty of the sclerotia from Brussels sprouts were recovered in various stages of preservation. Thirteen of these from nine of the fifteen flats were covered with pycnidia of *Coniothyrium*. Parasitized sclerotia disintegrate readily; therefore, the thirteen sclerotia having pycnidia of *Coniothyrium* probably represented only a portion of those actually parasitized. None of the sclerotia from sterile oats was parasitized by *Coniothyrium*. The presence of *Coniothyrium* on the sclerotia from Brussels sprouts and its absence in the same flats from those produced on sterile oats is assumed to be evidence that some of the sclerotia from the first-named source were either infected or had spores of *Coniothyrium* on them at the time they were collected.

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[1] The assistance of R. E. Bardin, R. W. Davidson, L. C. Erickson, H. N. Hansen and W. C. Snyder in the course of this study is hereby gratefully acknowledged.

Inasmuch as the fungus parasitic on sclerotia does not conform to the description of any known species of *Coniothyrium*, it is herein described as a new species.

Coniothyrium minitans n. sp.

Pycnidia globosa, superficialia, basi angusto affixa, levia, muro atro carbonaceo praedita, 200–700 μ in diam., ostioli centrali plerumque sporis exsudis obscurato; pycnidiosporae in massa atra liquida exsudantes, brunneae, ellipsoideae, leves vel in vetustate minute asperatae, 4–6 × 3.5–4 μ. Sclerotia *Sclerotinia sclerotiorum* in California parasitans.[2]

Pycnidia globose, superficial, attached by a narrow base, smooth with a black carbonaceous covering, 200–700 μ in diameter; ostiole centrally located, usually obscured by exuded spores; pycnidiospores exuding as a black liquid mass, individual spores brown, ellipsoid, smooth or minutely roughened with age, 4–6 × 3.5–4 μ. Parasitic on sclerotia of *Sclerotinia sclerotiorum*.

The type specimen on sclerotia of *Sclerotinia sclerotiorum* collected on diseased Brussels sprouts, January 1946 near Carmel, Monterey Co., California, has been deposited with the Division of Mycology and Disease Survey, Bureau of Plant Industry, Soils, and Agricultural Engineering, United States Department of Agriculture.

DESCRIPTION IN CULTURE

The pycnidiospores germinate readily on potato-dextrose agar or water agar and all cultural studies were made from single spore cultures. The fungus grows slowly on Difco potato-dextrose agar forming in seven days a mat 30 to 35 mm. in diameter at room temperature from 20 to 25° C.; mat white, azonate, curly cottony to woolly with denser tufts near the center which are pycnidial initials; margin narrow, appressed, finely fimbriate.

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[2] Latin description prepared by Edith K. Cash, Associate Mycologist, Division of Mycology and Disease Survey.

In fourteen days mat from 60 to 70 mm. in diameter with a distinct central zone covered with numerous superficial dark colored pycnidia or with lighter pycnidial initials buried in the fine woolly surface mycelium; outer zone wide, white, azonate.

With further aging the mat surface becomes covered with numerous uniformly spaced dark pycnidia, these variable in size, ranging from 160 to 600 μ in diameter; the pycnidiospores exude from the pycnidia as a black liquid mass and correspond in size and shape with those described for spores produced on sclerotia (FIG. 1, *C*). The undersurface of the mat is dark only in numerous spots corresponding to location of pycnidia on the surface. Hyphae from growing margin of culture are 2–6 μ in diameter,

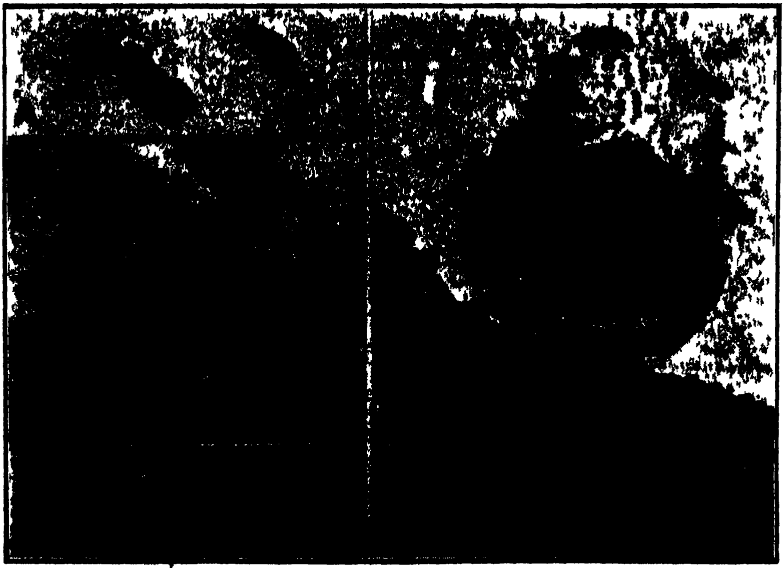

FIG. 1, *A–D*, *Coniothyrium minitans*. *A*, Pycnidia that developed on filter paper around parasitized sclerotia of *Sclerotinia sclerotiorum*. *B*, Pycnidia on sclerotia of *S. minor* in a Petri dish culture. *C*, Pycnidiospores. *D*, Cross-section of pycnidium on the surface of a parasitized sclerotium of *S. sclerotiorum*.

smooth, simple, with numerous septations common in the larger hyphae; in older parts of culture yellowish, roughened hyphae occur.

Growth at constant temperatures on Difco potato-dextrose agar expressed as radial growth in millimeters in seven days in dark as follows: 10° C., 4 mm.; 15°, 12 mm.; 20°, 20 mm.; 25°, 4 mm.; 30°, no growth.

INOCULATION EXPERIMENTS

In a laboratory inoculation experiment large sclerotia of *Sclerotinia sclerotiorum* produced on sterile oat cultures were placed on moist sterile blotting paper in Petri dishes. A droplet containing *Coniothyrium* spores in suspension was placed on the surface of each sclerotium. The sclerotia were then incubated in the laboratory at room temperature. In ten days the sclerotia and adjacent blotting paper were covered with pycnidia of *Coniothyrium minitans* (FIG. 1, *A*). On sectioning a parasitized sclerotium the structure of the pycnidium and the ramifications of the mycelium of *Coniothyrium* in the sclerotium could be clearly noted (FIG. 1, *D*). The parasitized sclerotia had lost their firm texture and become soft, and disintegrated readily when handled.

In another inoculation experiment a spore suspension of *Coniothyrium* was spread over sclerotia of both *S. sclerotiorum* and *S. minor* growing in pure culture in Petri dishes. Pycnidia quickly developed on the surface of the sclerotia (FIG. 1, *B*). Pycnidia did not develop on the mycelium, and the fungus appeared to be present only on the sclerotia.

In a third inoculation experiment, which was started on December 6, 1945, sclerotia of *S. sclerotiorum* produced on sterile oat cultures in the laboratory were used. The check or treatment *1* consisted in burying twenty-five sclerotia of comparable size ½ inch deep in sterile sand in four small wooden flats. Two of the flats were maintained on the greenhouse floor at temperatures ranging from 50 to 75° F. and the remaining two were placed outside on the north side of the greenhouse where the temperatures varied from 30 to 65° F. Treatment *2* consisted in immersing the sclerotia in a spore suspension of *Coniothyrium minitans* after which they were buried ½ inch deep in sterile sand. In treatment *3*, the sclerotia were first buried, after which the surface of the sand was watered with a suspension of *Coniothyrium* spores. In both treatments *2* and *3*, as in the checks, twenty-five sclerotia were used per flat and two replications of each were maintained in the greenhouse and two outside. The flats were watered daily in order to provide optimum moisture conditions for the formation of apothecia.

Apothecia first appeared on January 10, 1946, in the check flats kept in the greenhouse and the peak of development was reached on February 25 (Table 1). During this period no apothecia developed in treatment *2* but a considerable number appeared in replication *A* of treatment *3* and a lesser number in replication *B*. However, apothecial formation was of shorter duration than in the check and by March 19 the apothecia had disintegrated almost completely. The experiment inside the greenhouse was terminated on this date and the sclerotia recovered by washing. All sclerotia in treatment *2* had softened, the outer dark colored coating came off in the washing process and only the pink, gelatinous inner tissues of a few sclerotia were recovered. Many of the sclerotia had turned into a dark mass of *Coniothyrium* spores. In treat-

TABLE 1

APOTHECIA PRODUCTION BY SCLEROTIA OF SCLEROTINIA SCLEROTIORUM INOCULATED WITH SPORES OF CONIOTHYRIUM MINITANS

Treatment	Replicates	Number of Apothecia Present on:								
		1/17	1/24	1/30	2/5	2/17	2/25	3/12	3/19	4/2
In greenhouse:										
1. Check	A	7	17	18	31	53	58	27	46	—
Check	B	1	3	3	6	37	57	49	27	—
2. Spores on sclerotia	A	0	0	0	0	0	0	0	0	—
Spores on sclerotia	B	0	0	0	0	0	0	0	0	—
3. Spores on soil surface	A	0	0	0	3	20	21	13	1	—
Spores on soil surface	B	0	0	0	0	2	2	1	0	—
Outside greenhouse:										
1. Check	A	0	0	0	0	0	7	77	82	84
Check	B	0	0	0	0	0	13	84	78	79
2. Spores on sclerotia	A	0	0	0	0	0	5	12	11	11
Spores on sclerotia	B	0	0	0	0	0	1	4	1	0
3. Spores on soil surface	A	0	0	0	0	0	16	28	24	24
Spores on soil surface	B	0	0	0	0	0	11	22	27	23

ment *3*, the sclerotia were likewise badly softened with the exception of the few that produced apothecia. The sclerotia in the checks were firm and a number were still producing apothecia.

Apothecial formation was much slower in the flats kept outside the greenhouse than in those maintained within, because of the lower outside temperatures. The first apothecia did not develop until February 17, or more than a month after those kept at more favorable temperatures. However, the peak of production was reached in a shorter period and more apothecia were produced in the checks and in treatments *2* and *3*. Inasmuch as *Coniothyrium minitans* grows best at 20° C. or approximately 68° F., it would seem that its ability to parasitize sclerotia was affected by temperature. However, even at the lower temperatures prevailing outside the greenhouse it caused a marked reduction in apothecial production when the surface of the sand was inoculated by a spore suspension. The apothecia that formed in treatments *2* and *3* developed brownish spots that appeared to be areas parasitized by *Coniothyrium*. No such spots appeared in the checks. When the sclerotia were recovered by washing, those in treatments *2* and *3* were uniformly softened and disintegrated in contrast to the firm but shriveled condition of those in the checks.

SUMMARY

Coniothyrium minitans was isolated from parasitized sclerotia of *Sclerotinia sclerotiorum* obtained from Sclerotinia-diseased guayule from near Salinas, California, and from Brussels sprouts from near Carmel. Laboratory inoculation experiments demonstrated that sclerotia of both *S. sclerotiorum* and *S. minor* were readily parasitized by the fungus and furnished suitable substrata for the development of pycnidia. In an inoculation experiment the formation of apothecia from sclerotia of *S. sclerotiorum* in sterile sand was suppressed when pycnidiospores of *C. minitans* were brought in direct contact with sclerotia and when they were poured on the surface of the sand. The results of these experiments suggest the possibility of biological control of *Sclerotinia* spp. by *C. minitans*.

SCHOOL OF FORESTRY,
UNIVERSITY OF GEORGIA,
ATHENS, GEORGIA.

INCREASED PERITHECIUM FORMATION AND HYBRIDIZATION IN FLOODED CULTURES OF A HOMOTHALLIC ASCOMYCETE

SHUH-WEI HWANG, H. N. HANSEN, AND WILLIAM C. SNYDER

(WITH 1 FIGURE)

While studying variation phenomena in a homothallic form of *Hypomyces solani* (Rke. et Berth.) Snyder et Hansen, Hwang (1946) noted that perithecia were formed sooner and in greater abundance when full-grown cultures in test tubes were flooded with sterile water to obtain conidia for single-spore transfer (FIG. 1). A similar response in perithecium production was obtained by flooding full-grown cultures of *Gibberella roseum* (Lk.) Snyder et Hansen. This observation indicated a means by which perithecium formation may be induced with regularity and in increased amounts in such homothallic ascomycetes where otherwise it is erratic or scant. The procedure has since proven useful in studies on the ascigerous stages of these fungi.

This behavior of cultures following flooding, suggested that fertilization in these and perhaps in other homothallic ascomycetes may take place through a trichogyne or flexuous hypha. Furthermore, it suggested the possibility of hybridizing such forms by flooding cultures with spore suspensions from other thalli. The flooding technique has been used successfully by Dimock (1937), and by Hansen and Snyder (1943) in hybridizing heterothallic forms of *H. solani*, and by Dodge (1932) and others in various heterothallic ascomycetes.

Accordingly, four-week-old cultures of the wild type, *N*, of homothallic *H. solani*, were flooded with a conidial suspension of a distinctive mutant, *El*. This *El* type had never been observed by Hwang (1946) to arise directly from *N*, but only secondarily from a primary mutant, *B*. Other cultures of *N*, flooded with sterile water, served as controls.

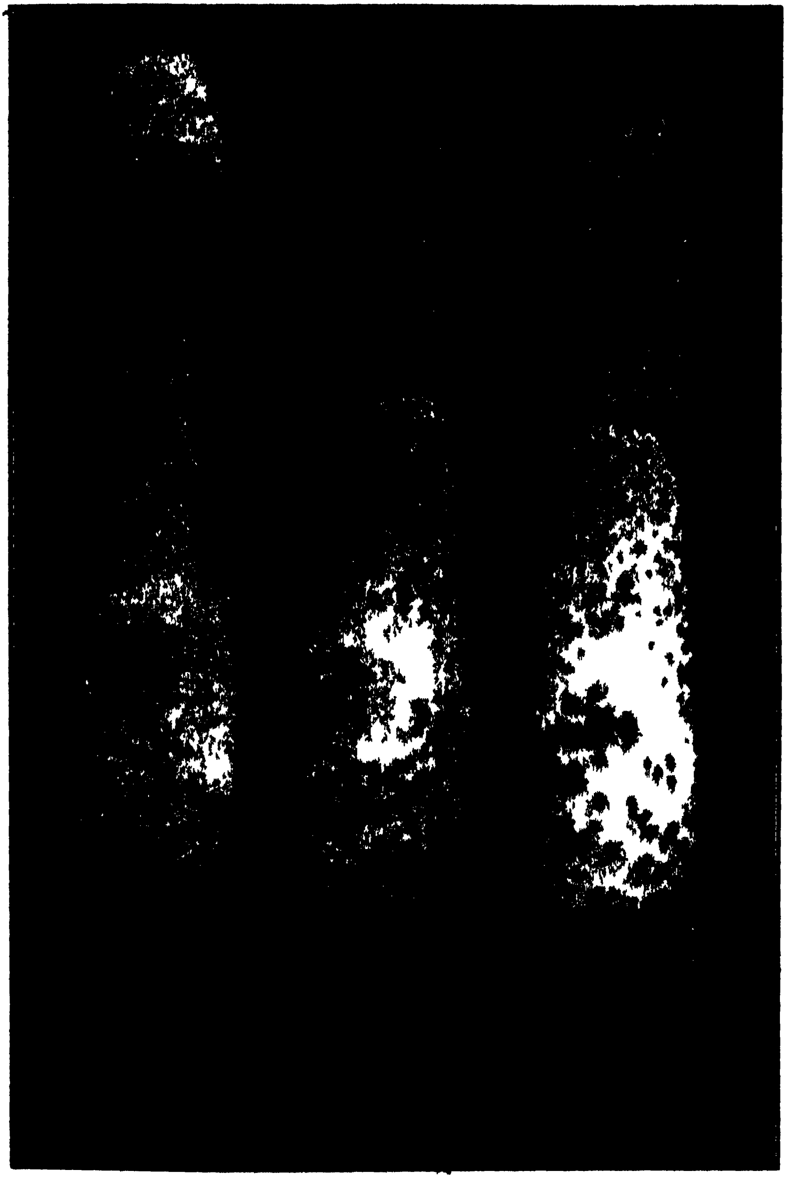

FIG. 1. The two cultures on the right were flooded with sterile water whereas that on the left was not treated. Note the marked increase in perithecium production on the right.

Mature perithecia were obtained in about a week on all flooded cultures. Four single-ascospore transfers were made at this time from each of a number of perithecia from cultures treated in both ways. The precaution was taken to examine each single ascospore under the compound microscope at the time of its transfer. Results of the ascosporic analysis *N* × *El* are shown in table 1.

TABLE 1

SINGLE ASCOSPORE ANALYSIS OF THE CROSS *N* × *El*, IN HOMOTHALLIC *H. solani*

Progeny	No. of Perithecia Tested																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
N	4	4	3	4	4	4	3	3	0	4	2	0	0	4	3	4	46
El	0	0	1	0	0	0	1	1	4	0	2	4	4	0	1	0	18

Thus when *El* was applied as functional male to *N*, it was recovered by means of ascospores 18 times out of a total of 64 monoascosporic transfers representing 16 perithecia. A similar number of monoascosporic cultures from perithecia of *N* flooded only with sterile water yielded no *El*. Although *El* has been recovered in several tests from the cross *N* × *El*, so far hybridization in the reciprocal cross *El* × *N* has failed to occur.

In subsequent tests a modification of the flooding technique was adopted. This consists in spraying the culture with sterile water, or a spore suspension as the case may be, by means of a sterilized DeVilbiss atomizer the air vents of which have been loosely plugged with cotton. One to three discharges of the spray into the culture have given better and more normal perithecium development with less matting of the fungus growth than has flooding.

Whereas hybridization of homothallic *H. solani* has been accomplished repeatedly by the flooding and spraying techniques, it has resulted only rarely from the familiar hybridization procedure of pairing thalli and allowing the colonies to approach each other or by permitting the mycelia to intermingle from the start. This pairing method used successfully for other fungi has not only proven inferior in hybridizing either the homothallic or heterothallic forms of *H. solani* but has failed to insure adequate perithecium development in them.

Hybridization in homothallic forms of this kind provides an additional approach to a study of their genetic constitution and inheritance.

SUMMARY

Flooding or atomizing full-grown cultures of a homothallic form of *Hypomyces solani* with water alone hastened and increased perithecium formation. By applying conidial suspensions in both of these ways hybridization between two cultural strains was effected.

DIVISION OF PLANT PATHOLOGY,
UNIVERSITY OF CALIFORNIA,
BERKELEY, CALIFORNIA

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MICROSPORUM AUDOUINI: THE EFFECT OF YEAST EXTRACT, THIAMINE, PYRIDOXINE, AND BACILLUS WEIDMANIENSIS ON THE COLONY CHARACTERISTICS AND MACROCONIDIAL FORMATION *

ELIZABETH L. HAZEN

(WITH 4 FIGURES)

The dermatophytes consist of three genera, *Microsporum, Trichophyton,* and *Epidermophyton,* characterized by distinctive cultural and morphologic characters. *Microsporum* is represented by flat, spreading, fluffy, downy or powdery growth, varying in color from white to tan; by single-celled clavate microconidia; and by long spindle-shaped macroconidia with few to many septa. The genus consists of at least three species, *Microsporum canis (lanosum, felineum), Microsporum gypseum (fulvum),* and *Microsporum audouini. Microsporum canis* and *Microsporum gypseum* grow luxuriantly and produce macroconidia abundantly on Sabouraud's dextrose, maltose, or honey agar. Specific identification of *Microsporum audouini,* however, cannot always be made on these media because growth is sparse and macroconidia are produced irregularly or not at all.

Sabouraud (1) obtained heavy growth and found macroconidia in *Microsporum audouini* on dextrose and maltose agars. Conant (2) discovered that species of *Microsporum* of animal origin grew profusely on polished rice grains and produced macroconidia in abundance, but that *Microsporum audouini* grew poorly, showing no aerial growth and producing no macroconidia. Benedek (3) found, accidentally, that a culture of *Microsporum audouini* contaminated with a bacillus that he named *Bacillus weidmaniensis* grew well on polished rice grains and produced long, thick-walled septate and non-septate spindle-shaped spores. He had no difficulty in confirming his observation with pure cultures of *Microsporum audouini* inoculated on rice grains to which the bacillus was added. The growth of *Microsporum audouini* with production of macroconidia on polished rice grains infected with *Bacillus weidmaniensis* has been confirmed by Dr. Rhoda W. Benham (unpublished data).

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* This work was done in the Department of Dermatology, College of Physicians and Surgeons, Columbia University, in association with Dr. Rhoda Benham to whom I wish to express thanks for advice and suggestions throughout the study.

From the Division of Laboratories and Research, New York State Department of Health, Branch Laboratory, 339 East 25th Street, New York, N. Y.

This stimulation by *Bacillus weidmaniensis* of the growth of *Microsporum audouini* with production of macroconidia naturally raised the question as to the nature of the growth-promoting substances. The presence of the nutritional factors, produced by the actively-growing bacillus, suggested that they might be of the nature of vitamins and for this reason the study of yeast extract, as well as some of the single vitamins of the B complex, for their growth-promoting properties for *Microsporum audouini,* was undertaken. The results of the preliminary study of the problem are presented herein.

METHOD

Eighteen pure cultures of *Microsporum audouini,* recently isolated from the scalp of children who came to the Vanderbilt Clinic for treatment for *Tinea capitis,* were used. Honey agar, pH 5.5, containing 60 grams of commercial honey, 10 grams of peptone, 20 grams of agar and 1000 ml. of distilled water, and autoclaved at fifteen pounds pressure, was adopted as a basal medium to which were added the substances under investigation. This medium was recognized not to be vitamin-free, but it seemed a desirable one for the preliminary investigation since it is satisfactory for isolation, but unsuitable as a single medium for specific identification of *Microsporum audouini.*

The following substances were tested for their effect upon growth and macroconidia production particularly: Yeast extract, thiamine, pyridoxine, thiamine and pyridoxine, and polished rice grains inoculated previously with *Bacillus weidmaniensis.* Bacto-yeast extract, a dehydrated Difco product, was used. A fresh five per cent solution was prepared in sterile distilled water and passed through a Berkefeld filter. The filtrate was added to the basal medium (cooled to approximately 45° C.) in an amount equal to 5 mg. of yeast extract per ml. of medium. Fresh solutions of the yeast extract were prepared for each series of experiments. Solutions of thiamine chloride and pyridoxine hydrochloride were prepared aseptically in sterile distilled water, and these were added, respectively, to the basal medium in amounts equal to 0.5 γ to 1 γ per ml. of medium. Sterile polished rice grains in 250 ml. flasks were inoculated with two or three loopfuls of a fresh culture of *Bacillus weidmaniensis* on honey medium. They were left at room temperature for forty-eight or seventy-two hours so as to have good growth of the bacillus on the surface of the rice grains at the time of inoculation with the fungus.

The original primary cultures of *Microsporum audouini* on honey, dextrose, or maltose agar served, in the majority of instances, as the seed culture for the experimental media. (The cultures were maintained on honey agar.) In none of the primary cultures examined microscopically were macroconidia found. Small inocula of the seed culture were placed in the center of Petri dishes containing about 30 ml. of medium and left at room temperature for eight weeks or longer. The cultures were usually inoculated in duplicate, and microscopic examinations were made of film preparations for the presence of macroconidia, when they were about three weeks old and, thereafter, at weekly intervals, as far as possible, for from six to eight weeks. Bits of the fungus were taken from the plate, placed on a slide in sodium hydroxide-glycerol solution, and teased apart with a dissecting needle; over these a cover slip was dropped. Such preparations were then searched carefully for macroconidia and a count was made. The number of macroconidia in a culture was roughly estimated from the number found in the film preparations on the particular date.

Eighteen cultures were studied on both honey agar and honey agar plus yeast extract, but only nine of them were studied with the vitamin combinations and with polished rice grains, and rice grains inoculated with actively growing *Bacillus weidmaniensis*.

EFFECT OF YEAST EXTRACT

Macroscopic.—The growth on honey agar to which yeast extract had been added was heavier and resembled more closely than that on honey agar alone, Sabouraud's (2) description and photographs of *Microsporum audouini* on dextrose and maltose agar. The typical colony on honey agar is flat with scanty, grayish white, aerial mycelium, and on the reverse side shows a rose-brown pigment; with the addition of yeast extract, a typical colony showed

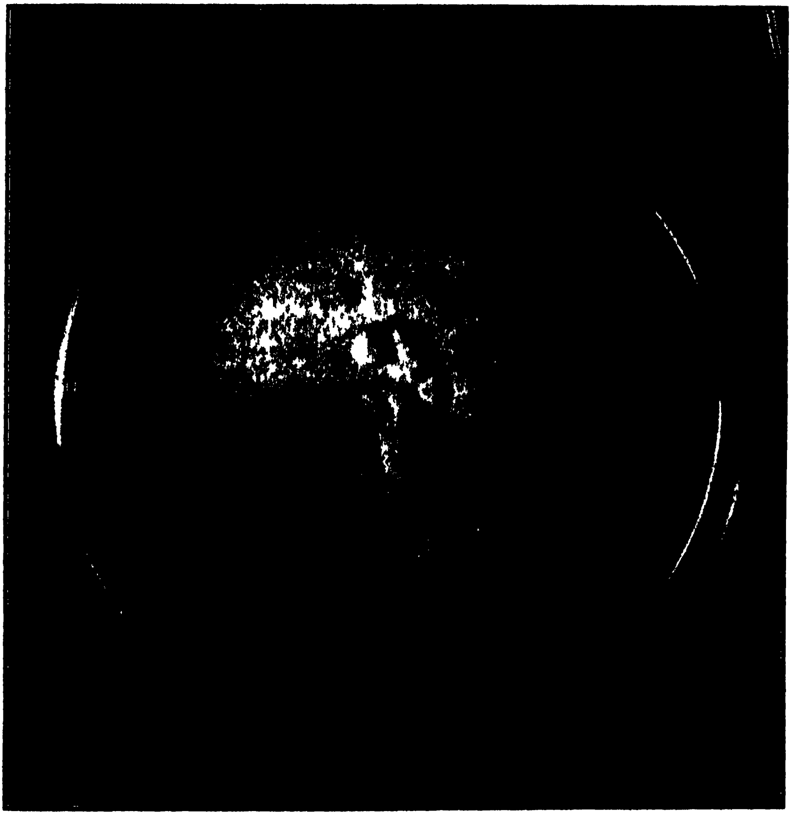

FIG. 1. *Microsporum audouini;* honey agar, 24 days.

a heavy, grayish-white, decumbent mycelium and deep radial grooves, and on the reverse side prominent concentric circles and a deep rose-brown pigment (FIGS. 1 and 2). When a different brand of peptone was used, the colonies varied in that the aerial mycelium was not so heavy and the radial furrows were shallow or lacking. This phenomenon requires investigation.

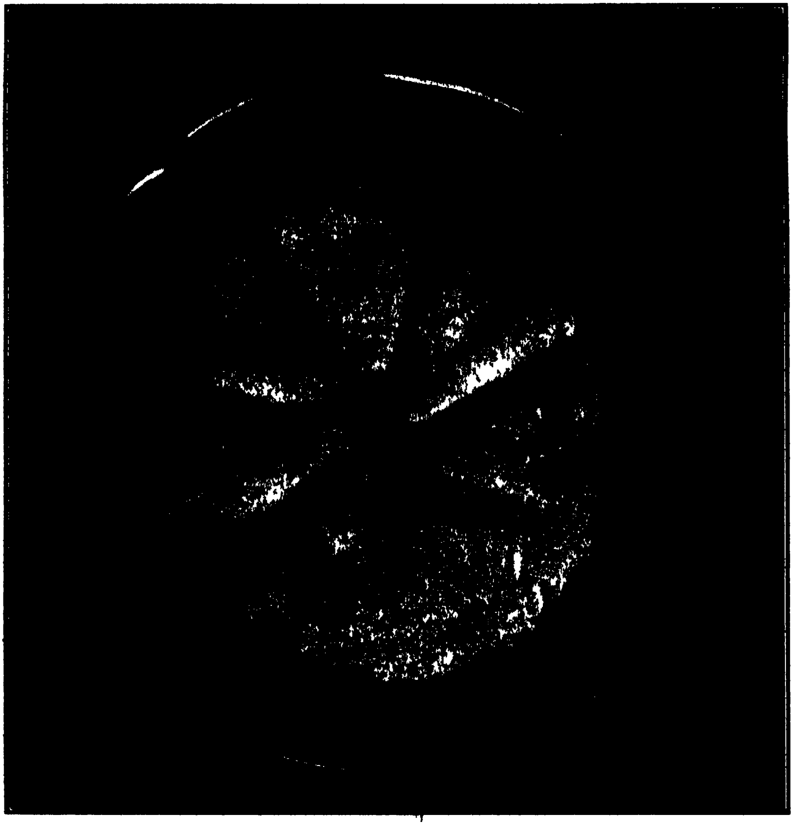

FIG. 2. *Microsporum audouini,* honey agar plus yeast extract, 24 days.

Microscopic.—In only four of the eighteen cultures were macroconidia found on honey agar and in only one instance in appreciable numbers, whereas with the addition of yeast extract all but one culture produced macroconidia (Table I). Nine showed a count of from six to ten or more macroconidia in a culture mount,

TABLE I

MACROCONIDIAL FORMATION OF M. AUDOUINI ON VARIOUS MEDIA

Culture No.	Estimate of Number of Macroconidia in Culture*							
	Approx. Age of Culture (wks.)	Honey Agar	Honey Agar plus Yeast Extract (5 mg. per ml.)	Honey Agar plus Thiamine (0.5 to 1γ per ml.)	Honey Agar plus Pyridoxine (0.5 to 1γ per ml.)	Honey Agar plus Thiamine and Pyridoxine (0.5 to 1γ of each per ml.)	Polished Rice Grains	Polished Rice Grains with *B. weidmaniensis*
1	6	++++	++++	++++	++++	++++	–	++++
2	6	–	+	–	+	–	–	++
3	7	–	+	–	–	no culture	–	+
4	7	+	++++	++++	++++	++	–	++++
5	8	–	+	–	+	–	–	+
6	8	–	+	–	–	–	contaminated	++
7	8	–	++++	–	+	–	++	++
8	3½	–	+	–	–	–	–	++
9	6	–	++++	–	+	+	–	++++
10	8	–	–					
11	5	+	+					
12	4	+	++++					
13	7	–	+					
14	8	–	++					
15	8	–	++++					
16	8	–	+					
17	6	–	++					
18	6	–	++					

* No spores = –
1–5 spores = +
6–10 spores = ++
More than 10 spores = ++++.

and eight showed from one to five in a mount. The spores were typical in morphology, long, thick-walled, spindle-shaped and septate, though short and long non-septate spores were observed (FIGS. 3 and 4).

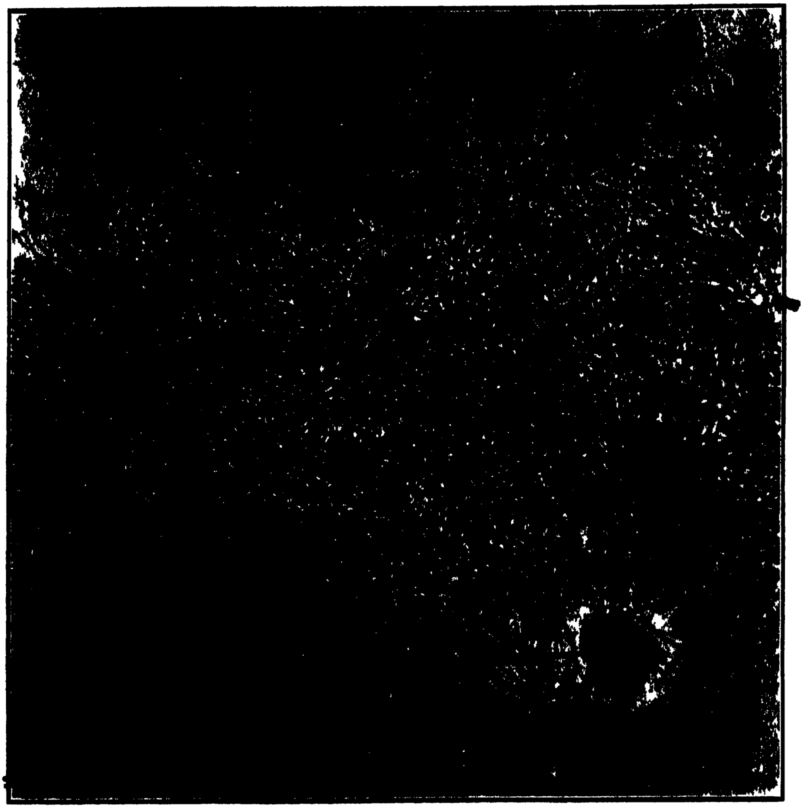

FIG. 3. Macroconidia of *Microsporum audouini* formed on honey plus yeast extract.

EFFECT OF INDIVIDUAL VITAMINS

Nine of the cultures were studied by addition to honey agar of individual vitamins of the B complex, thiamine and pyridoxine, and a combination of the two.

Macroscopic.—Thiamine was without effect except in two instances; cultures Nos. 1 and 4, which also produced macroconidia

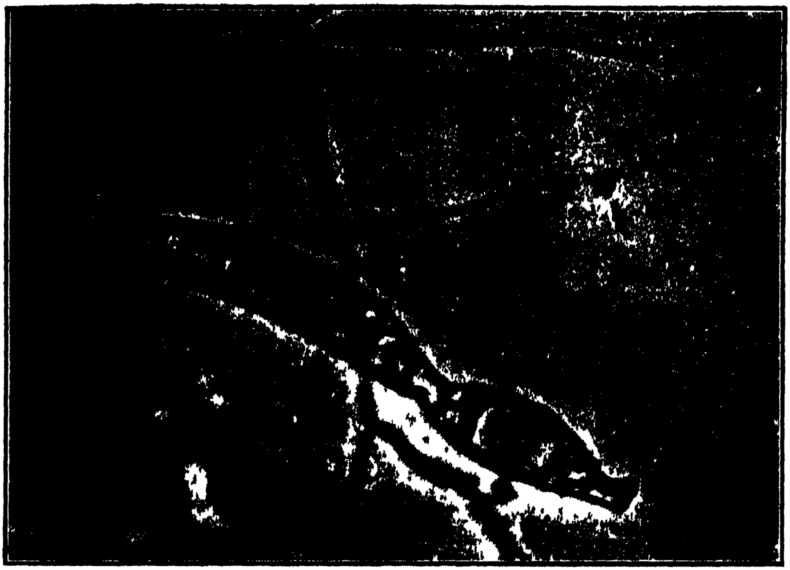

FIG. 4. Macroconidia of *Microsporum audouini* found on honey plus yeast extract greatly enlarged.

on the honey agar. Pyridoxine was somewhat more effective, macroconidia being produced in all but three of the cultures tested; these three (Nos. 3, 6 and 8) had shown a few spores on the yeast-extract agar. Strangely enough, a mixture of the two vitamins was not as effective as pyridoxine alone.

COMPARISON WITH CULTURES ON RICE GRAINS

For comparison, nine of the same cultures were grown on polished rice grains, and on rice grains infected with *B. weidmaniensis* (Table 1). In one culture (No. 7) macroconidia were found on the rice grains alone. No explanation can be offered, since the culture was not one which formed macroconidia on honey agar without additional growth factors. With the addition of *B. weidmaniensis* to rice grains, all of the cultures produced macroconidia in numbers comparable to those on the yeast-extract medium. These findings support the assumption that the substances produced by the bacillus may be in the nature of vitamins.

SUMMARY AND DISCUSSION

Yeast-extract added to honey agar resulted in a marked increase in the vegetative growth of *M. audouini* and in its production of macroconidia. Its effect upon macroconidia production was comparable to that of *B. weidmaniensis.* With the substitution of pyridoxine for the yeast extract, the abundance of macroscopic growth differed little, if at all, from that on honey medium alone although an increase in macroconidia production occurred. Addition of thiamine, or thiamine and pyridoxine, did not, under the conditions studied, result in increased growth or macroconidia production.

It would appear that *M. audouini* is deficient in certain factors essential to its profuse growth and to the development of macroconidia. The routine Sabouraud's honey and dextrose agar media now in use are also apparently lacking in these nutritional factors or contain them in insufficient amounts. For many years mycologists (2, 4, 5) have recognized that these media prepared from the American or English materials were deficient in some growth substances that were present in the French products with which Sabouraud worked. Thus, as Conant (2) has stated, Sabouraud's excellent photographs for comparison of cultures on artificial media were of little value when it became difficult to secure comparable macroscopic pictures of the fungi.

Growth factors essential to the development of *M. audouini* are present in yeast-extract and are produced by *B. weidmaniensis.* These factors are probably identical. The indications are that the kind of peptone used in the medium to which yeast-extract is added is an important factor to maximal development of the fungus.

In order to further clarify the nature and effect of the growth-promoting factors involved here, further studies are in progress with a vitamin-free basal medium of known composition to which vitamins of the B complex will be added singly and in various combinations.

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FOMES ROBUSTUS, A HEART-ROT FUNGUS ON CACTI AND OTHER DESERT PLANTS

Ross W. Davidson and James L. Mielke[1]

(with 3 figures)

Heart rots are common in most trees and sometimes occur in shrubs with small woody stems, but wood-decaying Hymenomycetes have not been reported as causing decay of the woody skeleton in living cacti. In 1941 Baxter (1) described *Poria carnegiea* Baxter, which he collected on the woody ribs of fallen plants of the giant cactus or saguaro (*Cereus giganteus* Engelm.). He states "This plant is the first *Poria* described on cactus." In 1941, during investigations of disease and decline of the giant cactus in Arizona, L. S. Gill and P. C. Lightle of the Division of Forest Pathology observed sporophores of a *Fomes* on the bark-like tissues at the base of arms of living plants and also near the base of the main stem on ribs exposed as the result of injury.

Specimens of the *Fomes* were collected and sent to the senior author for identification and later additional collections of similar specimens from cacti and other desert shrubs and trees were obtained by the junior author and others. Also, older collections from certain woody plants filed in the Forest Pathology herbarium at Albuquerque were examined.

COMPARISON OF THE CACTUS FOMES WITH DESCRIBED SPECIES

In color of context, pore size, and spore color and size, the *Fomes* on cacti in the Southwest is similar to the larger *Fomes robustus* Karst., which is common in Europe and is known to occur occasionally in the Eastern States on oaks (3) and birches (8). Apparently it has not been reported from the Southwest unless *F. texanus* proves to be the same.

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[1] Pathologists, Division of Forest Pathology, Bureau of Plant Industry, Soils, and Agricultural Engineering, U. S. Department of Agriculture.

FIG. 1, *A–D; Fomes robustus. A,* Sporophore on giant cactus (*Cereus giganteus*); *B,* Close up of the sporophore blocked out in *A. C,* Sporophores on Paloverde (*Cercidium microphyllum*) and associated decay. *D,* Close up of same sporophores as shown in *C.* (Photographs *C* and *D* by Marvin H Frost.)

The sporophores from cacti, particularly those from saguaro, were mostly small (FIG. 1, *A* & *B*, and FIG. 2, *A* & *B*) approximating in size those of *Fomes arctostaphyli* Long, which was collected on several species of *Arctostaphylos* in Arizona and described by Long in 1917 (6). However, the few spores observed in some of the *Fomes* specimens from cacti were larger than those of *F. arctostaphyli* and the color of the context tissue was not quite the same. The closely related species, *F. igniarius* (Fr.) Kickx., also differs in spore size, context color, and other characters.

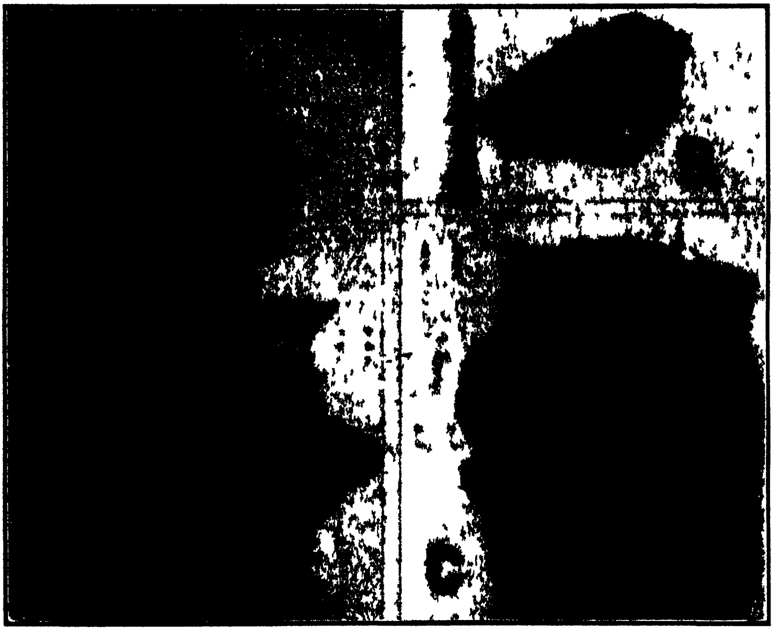

FIG. 2, *A–C; Fomes robustus·* *A,* Sporophore on trunk of *Opuntia versicolor; B,* Young sporophores from giant cactus; *C,* Sporophore on trunk of *Cowania stansburiana.* (*A* and *C* about ⅗ natural size)

Complete descriptions of three species of *Fomes* on *Juniperus* spp. in the Southwest are given by Hedgcock and Long (4). Of these *F. juniperinus* (Schrenk) Sacc. & Syd. is very different in context color, and *F. earlei* (Murr.) Sacc. & D. Sacc has spores more nearly the same size as the cactus fungus but the pores are much larger. *F. texanus* (Murr.) Hedgc. & Long, the other species, is similar in general color and pore size but the spores are recorded as smaller (3–4 μ) by Murrill (7), and Hedgcock and Long (4). However, the latter state that spores are rarely found, and it seems doubtful that the size as given by them is correct. Lloyd (5) states that spores are 5–6 μ and not as described.

The only other similar species known to occur in the Southwest is one that has been collected on the woody legumes *Prosopis* spp. and *Acacia* spp. It has smaller dark brown spores and has been referred to the species *Fomes rimosus* (Berk.) Cke. (5).

PURE CULTURE STUDIES

Cultures were obtained from fresh sporophores of the *Fomes* on cacti (FIG. 3, *A–E*) and from other of the small forms from the Southwest to aid in identifying the species. These included, in addition to the cactus form, cultures from *F. rimosus*-like sporophores collected on *Prosopis* and *Acacia,* and from *Fomes arctostaphyli* and *F. texanus* (FIG. 3, *F–I*). Cultures of most of the other common species of *Fomes* were available in the stock culture collection of the Division of Forest Pathology at Beltsville, Md. (2, 3).

A comparison of cultures shows that *Fomes arctostaphyli* and *F. igniarius* are distinct species and that both are quite different from the cactus *Fomes. F. rimosus* from the Southwest is in general similar to the eastern *F. rimosus* that is so common on *Robinia pseudoacacia* L., but a more careful comparison might reveal some consistent minor differences. Growth rate of the *Prosopis* fungus is about the same as that of the *Fomes* on cacti but mat color and texture are different.

The one available culture of *Fomes texanus,* the species that appears to be the most closely related of the Southwest forms, was similar in color and texture of mat to the cactus fungus but grew much more slowly (FIG. 1,*F*). In general the cactus fungus was very similar in growth characteristics to eastern cultures of *F. robustus* from oaks. Cultures of *F. robustus* have been described and illustrated by Campbell (2) and by Davidson, Campbell, and Vaughn (3).

The study of cultures further revealed that all isolates from sporophores on cacti were somewhat similar culturally although there was some variation in growth rate and mat texture. Also, cultures from *Fomes* sporophores collected on several species of living shrubs and trees were more like those from cacti. These other hosts are listed later following the description of the fungus.

TYPE OF DECAY AND HOST RELATIONSHIP

All of the species of *Fomes* mentioned in the foregoing account are known to sporulate on and cause heart rots of living trees and shrubs. Also, they all cause rots of a white, yellowish, or tan color, depending upon the host. In no case is the rot of the brown carbonizing type. On the shrubs and trees the sporophores develop either at dead branch stubs or are associated with injuries of one kind or another that expose the heartwood. No evidence has been found indicating that any of the forms from the Southwest attack outer sapwood around the point of infection. However, in the Eastern States *F. robustus* has frequently been collected on rather restricted dead areas or cankers and is therefore believed to be somewhat pathogenic.

The *Fomes* on giant cactus is most commonly found on the hard, bark-like outer tissues at arm bases and occasionally occurs near the base of the main stem on woody ribs exposed as the result of injury. On chollas (*Opuntia* spp.) (FIG. 2, *C*) the sporophores develop on the main stem generally near ground level but occasionally they are found as high as eighteen inches above it. They occur at branch stubs or on injured areas where the woody skeleton is exposed. Decay is sometimes found extending upwards well into the branches or to a height of four feet or more.

Those saguaros that were broken off near ground level during wind storms were found to have their basal ribs badly rotted by the *Fomes*. Also, the fungus was isolated from ribs in the basal portion of arms that had fallen from living plants. In chollas the *Fomes* rots the woody skeleton near the base of the plants, impairing their mechanical support and causing them to fall over eventually and die.

Sporophores on cacti and several other hosts are similar to *F. robustus* but are much smaller, particularly on giant cactus, than re-

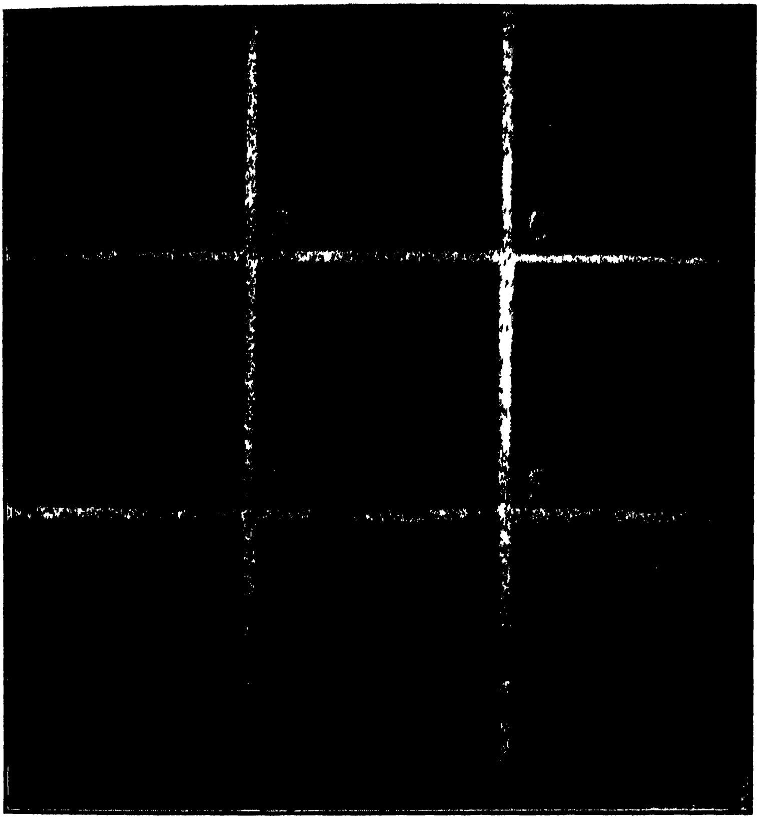

FIG. 3, *A–I;* Cultures of *Fomes* spp. from southwest desert plants. *A–E, Fomes robustus: A* and *B,* from *Cereus giganteus; C,* from *Opuntia fulgida; D,* from *Cowania stansburiana; E,* from *Canotia holacantha; F, Fomes texanus* from *Juniperus scopulorum; G* and *H, Fomes rimosus* from *Prosopis juliflora* and *Acacia greggii; I, Fomes arctostaphyli* from *Arctostaphylos* sp.

corded specimens of that species and the surface of sporophores is more rimose (FIG. 2, *A–D*). It is here considered as *F. robustus* or a closely related form of that species and the following description gives the outstanding characteristics of the fungus as it occurs in the Southwest:

Sporophores small, 1.5–10 cm. wide by 1–10 cm. by 1–7 cm. deep, hard, no crust, smooth when young, becoming strongly rimose, gray-black, margin smooth to velvety, yellow brown, context yellow brown, tubes stratose; pores 4–6 per mm., round; spores globose, hyaline to yellowish, 7–8 μ diameter.

It was especially common on living cacti and occasionally found on other living desert shrubs and small trees as follows:

Cereus giganteus F. P. No. 89760, collected Saguaro National Monument, Tucson, Arizona, July 17, 1941 by P. C. Lightle and L. S. Gill, No. 89669 coll. Saguaro National Monument Jan.–Feb., 1943 by J. W. Kimmey and J. L. Mielke, and No. 89670 coll. Saguaro Nat. Mon., Jan. 19, 1943 by Kimmey and Mielke; *Opuntia arbuscula* Engelm., No. 89673 coll. Saguaro Nat. Mon., Jan.–Feb., 1943 by Mielke and Kimmey; *Opuntia fulgida* Engelm., No. 89674 coll. Saguaro Nat. Mon., Jan. 18, 1943 by Kimmey and Mielke, and No. 66245, coll. Saguaro Nat. Mon., Apr. 24, 1943 by Mielke; *Opuntia versicolor* Engelm., No. 89757 coll. by P. C. Lightle, Saguaro Nat. Mon., May 1, 1941, and No. 89672, coll. Saguaro Nat. Mon., Jan.–Feb., 1943 by Mielke and Kimmey: *Canotia holacantha* Torr., No. 33338 coll. Estrella Mts., Maricopa Co., Arizona, Nov. 28, 1920 by L. N. Goodding, and No. 89279 coll. Tonto National Forest, Arizona, Oct. 20, 1938 by L. S. Gill and H. S. Palmer; *Cercidium microphyllum* (Torr.) Rose and Johnst., No. 89668 and No. 94250 coll. Saguaro Nat. Mon., Feb., 1943 by Mielke and Kimmey, and May, 1943 by Mielke; *Cowania stansburiana* Torr., No. 89665, coll. Camille Hills, Santa Cruz Co., Arizona, Jan. 20, 1943 by L. N. Goodding; *Vauquelinia californica* (Torr.) Sarg., No. 68946, coll. Jacumba, California, Jan. 1, 1929 by L. N. Goodding and S. B. Detwiler; *Larrea tridentata* (DC.) Coville, No. 89759 coll. Saguaro Nat. Mon., May 3, 1944 by Mielke.

SUMMARY

Sporophores of a small *Fomes* sp. from living giant cactus (*Cereus giganteus*) and some large, living chollas (*Opuntia* spp.) were studied and compared with *Fomes* sporophores from several other woody plants in the dry areas of southwestern United States. From morphological and cultural characters it was found to be closely related to *Fomes robustus* Karst., although sporophores were smaller and more rimose.

Sporophores from several associated desert shrubs and small trees other than cacti were found to be the same fungus. *Fomes texanus* from *Juniperus* is morphologically very similar to *F. robustus* but differs culturally from this form in its slower growth. *F. arctostaphyli,* which is another small species in the West, differs culturally and morphologically from *F. robustus* and is also culturally distinct from the large and somewhat closely related species *F. igniarius.*

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A NEW PHYTOPHTHORA CAUSING ROOT AND COLLAR ROT OF CINCHONA IN PERU[1]

Bowen S. Crandall[2]

In the course of investigations on the root and collar rot of cinchona in Peru (3) a *Phytophthora* was isolated consistently from the advancing margins of decay lesions in the basal portions of the roots and in the collar of plantation age trees and occasionally from all parts of the stem of nursery age seedlings and transplants.

There are practically no published accounts of cinchona root disease in the Western Hemisphere, but from the Asiatic regions the investigator is almost overwhelmed by the amount of material published on root diseases of cinchona. However, only recently and in but few instances has *Phytophthora* been described as the cause. Coster (2) in 1940 reported an undesignated species of *Phytophthora* associated with cinchona stripe canker in Java. Also in 1940 Thompson (6) reported *P. cinnamomi* Rands causing cinchona root rot in British Malaya. In 1936 Sawada (9) described a new species, *P. cinchonae* Saw., which he considered to be the cause of a top dieback. This dieback differed from other described dieback diseases of cinchona in that the infection court was apparently in the stem, with the fungus subsequently spreading upward to infect the top. Celino (1)[3] and Kheswalla (8), in reporting *P. palmivora* Butler as the cause of seedling

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[2] Pathologist, Office of Foreign Agricultural Relations, U. S. Department of Agriculture, and Chief, Department of Plant Pathology and Entomology, Estación Experimental Agricola de Tingo María, Peru, S. A. In cooperation with the Division of Forest Pathology, Bureau of Plant Industry, Soils, and Agricultural Engineering, U. S. Department of Agriculture.

[3] Published as *P. faberi* Maubl., a synonym of *P. palmivora* (11).

blights, and Crandall and Davis (4), in reporting *P. parasitica* Dast. as the cause of wilt and stem canker of cinchona, state that the infection took place in the tender tissue of the growing tip. In the work on the wilt and stem canker previously mentioned (4) and on this root and collar rot, *P. parasitica* and the *Phytophthora* described here commonly are found in the same plant. *P. parasitica* often spreads downward almost to the collar, especially in cortical tissue, whereas the new root-rot *Phytophthora* has often been isolated from tissue four to five inches up the stem in the case of *Cinchona pubescens* Vahl and to a height of eight inches in streak infections. In many cases involving nursery age plants, the new *Phytophthora* was found throughout the stem tissue and symptoms typical of top dieback were present. Although *P. cinchonae* does not appear to be closely related either to the *Phytophthora* described here or to the more closely related root-disease-producing *Phytophthora,* its description has been compared along with the others.

No description has been found in the literature of a *Phytophthora* resembling that of the one isolated from the root and collar rot of cinchona and it is here described as a new species. The specific name is derived from the Spanish word for the cinchona tree, which was adapted from the original Quechua Quina-quina. Two of the alkaloids extracted from the cinchona bark, quinine and quinidine, received their names from the same source.

Little cultural or morphological variation between isolates from the two known locations of the disease in Peru has been observed. Such variations as occur are no greater than those between isolates from the same locality. For this reason, measurements in the description that follows are based on an isolate from the point of original discovery of the disease, Fundo Sinchono. This isolate, No. C-67 of the culture collection of the Department of Plant Pathology and Entomology of the Estación Experimentál Agricola de Tingo María, is virulently pathogenic and was isolated from a case of root and collar rot in a plantation tree. Sporangia and zoospores were produced in abundance forty-eight hours after mycelia in blocks of ten-day-old oatmeal agar cultures were placed in running brook water. None were produced on solid media or when plates were flooded or when agar blocks with mycelium were placed in distilled water or liquid media. Oogonia and oospores were produced with regularity, although not abundantly, in old oatmeal agar cultures. The prolific production of chlamydospores by this species makes it extremely difficult to locate oogonia.

Phytophthora Quininea n. sp.[4]

Hyphae primum continuae, maturae sparse septatae, 3.7–8 μ in diam.; sporangia in aqua fluenti rivi abunde producta, non-papillata, ovata usque obpyriformia, 45.9–67.5 × 25.5–37.5 μ (media 53.8 × 31.1 μ), rare e tubulis, plerumque e 14–20 zoosporis globosis 8–10 μ in diam. in aqua germinantia; sporangiophora in diam. minoria quam hyphae gerentes, apicem versus subattenuata, simplicia, usque 75 μ longa, sporangia singula terminalia gerentia, deinde basim sporangii evacuati penetrantia et sporangia nova gerentia; chlamydosporae terminales et intercalares, brunneae, sphaericae, 45–90 μ; vesiculae abundantes, in forma et magnitudine irregulares: oogonia subsphaerica usque sphaerica, hyalina vel pallide flavidula, levia, 67.5–82.5 μ; oosporae globosae, hyalinae vel pallide flavidulae, granulosae, 48.7–63.7 μ; antheridia paragyna, in forma et magnitudine variabilia.

Hab. in radicibus et collaribus *Cinchonae officinalis* et *C. pubescentis*, Peru.

Hyphal growth similar to that of other Phytophthoras, continuous when young, becoming sparsely septate with age, 3.7–8.0 μ, mostly approaching 8.0 μ, in diameter; vegetative growth luxuriant and cottonlike on oatmeal agar, aerial hyphae scarce and cobweblike on cornmeal and potato dextrose agars, deep growing on and in the media, granular in appearance because of the early production of chlamydospores and vesicles; sporangia not observed on solid media but produced abundantly in running brook water, nonpapillate, ovate to obpyriform, widest near the base, 45.9–67.5 × 25.5–37.5 μ (average of 30 mature sporangia 53.8 × 31.1 μ), germinating in water, rarely by germ tubes, regularly by discharge of 14–20 globose to ellipsoidal zoospores, 8–10 μ in diameter; sporangiophores smaller in diameter than the hyphae from which they arise but within limits of hyphal size, tapering slightly toward the tip, simple, undifferentiated, up to 75 μ long, with single terminal sporangia, resuming growth through the base of the evacuated sporangium and producing new sporangia within or beyond the empty one; terminal and intercalary dark brown, spherical chlamydospores, 45–90 μ, produced abundantly after 132 hours on cornmeal and oatmeal agars; vesicles abundant and irregular in size and shape, giving a thickened appearance to the hyphae and causing irregular growth; oogonia subspherical to spherical, hyaline to faint yellow, smooth, 67.5–82.5 μ; oospores spherical, hyaline to faint yellow, granular, 48.7–63.7 μ; antheridia paragynous, irregular in shape, variable in size; in the host mycelium penetrating inner bark, phloem, cambium, and outermost wood layers, inter- and intra-cellular. Causing a destructive root and collar rot of Ledger form *Cinchona officinalis* L. and *C. pubescens* Vahl in Peru.

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[4] Latin description prepared by Miss Edith K. Cash, Associate Mycologist, Division of Mycology and Disease Survey, Bureau of Plant Industry, Soils, and Agricultural Engineering.

Phytophthora quininea is a member of the group containing *P. cinnamomi*, *P. erythroseptica* Pethyb., *P. cambivora* (Petri) Buis., *P. cryptogea* Pethyb. & Laff., *P. richardiae* Buis., *P. drechsleri* Tucker,[5] *P. megasperma* Drechsl. (6), and *P. fragariae* Hickman (7). Morphologically it resembles *P. cambivora* and *P. cinnamomi* in the production of chlamydospore-like vesicles, differs from *P. cinnamomi* specifically in the absence of the grapelike clusters of chlamydospores or chlamydospore-like bodies, and differs from all in this group excepting *P. megasperma* by the production of large oogonia with paragynous antheridia. *P. quininea* differs from *P. megasperma* by its larger oogonia and from it and the others in this group by the abundant production of large, true chlamydospores. *P. quininea* differs from *P. cinchonae* morphologically in that *P. cinchonae* is described as having sporangia with flattened papillae and of smaller size (18–68 × 13–38 μ, average 41.2 × 23.0 μ), produced both terminally and laterally on short sporangiophores (24–41 μ). No chlamydospores or oogonia are reported for *P. cinchonae*. Sawada's figure (9) of *P. cinchonae* shows non-papillate sporangia resuming growth through the evacuated sporangia, characteristic of the root-rot *Phytophthora* group. *P. cinchonae* has a lower minimum growth temperature (10° C.) and a higher optimum temperature (30° C.) than *P. quininea*.

P. quininea makes its optimum growth on cornmeal agar at pH 6.0. At this pH growth is regular. At pH 7.0 and 5.5 growth becomes irregular because of the production of vesicles. Almost no growth occurs at pH 8.5. When grown on cornmeal agar at pH 6.0 the optimum temperature for growth is 25° C. Growth occurred between 15° and 30° C. on cornmeal agar. At the optimum temperature of 25° C., *P. quininea* grew radially at the rate of 8 mm. per 24 hours.

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[5] For the preceding six species the descriptions as reviewed by Tucker (11) are used, together with additional information from the author's work with *P. cambivora* and *P. cinnamomi* (5).

P. quininea causes a disease of the root and collar tissue of Ledger form *C. officinalis* plantation trees and of nursery stock of this species and of *C. pubescens.*[6] The disease first manifests itself in the aboveground portions of the tree by the loss of the normal green color, giving the leaves a reddish appearance. This symptom is shortly followed by wilting and loss of all but the small terminal leaves prior to death. In the collar region an external swelling usually is present immediately above the invaded tissue. The fungus progresses into healthy tissue and produces internally reddish-brown wedge-shaped areas. The pathogenicity of *P. quininea* has been proved by inoculation on Ledger form *C. officinalis* and *C. pubescens* trees. In addition it has been found by inoculation that *C. officinalis*[7] from the Tambopata Valley of Peru and from Bolivia, and *C. micrantha* Ruiz & Pavon of Peru are susceptible to the disease.

The disease caused by *P. quininea* is known only at two localities in the upper Ucayali River basin in Peru: Hacienda Punizas, near La Merced on the Perene River, Department of Junin; and Fundo Sinchono, 60 km. east from Tingo María on the Tingo María-Pucallpa highway, on the upper headwaters of the Aguaytia River, Department of Loreto.

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LAGENIDIUM HUMANUM, A SAPROPHYTE ISOLATED ON DEAD HUMAN SKIN

John S. Karling

(with 39 figures)

In the course of a study of saprophytic chytrids which inhabit keratinized tissues of animals the author discovered a large species of *Lagenidium* on small pieces of dead human skin. Bits of this tissue had been added to a watered soil culture from a cemetery near Briarcliff, N.Y. as a substratum for isolating and growing *Rhizophydium keratinophilum* (3) and *Phlyctorhiza variabilis* (4). Within three days it became heavily infected with *Lagenidium* sp. and the last of the two keratinophilic chytrids mentioned above. This species of *Lagenidium* was subsequently isolated and grown in pure culture on agar containing minute amounts of peptone, dextrose and yeast extract. Therefore, it is not strictly keratinophilic although it has been found only in keratinized tissues in nature. It also grows fairly rapidly and produces large submerged colonies in a liquid medium containing 0.1 per cent peptone, 1.0 per cent dextrose and 0.1 per cent yeast extract. Further studies are now under way to determine more specifically its nutrient requirements and growth by dry weight.

The genus *Lagenidium* includes approximately twenty species (5, 6) some of which are imperfectly known, doubtful, and probably synonymous. All are reported to be weakly or strongly parasitic in algae, rhizoids of mosses, pollen grains, rotifers, mosquito larvae, copepods, *Daphne,* and eggs and newly-hatched individuals of the common blue crab. Only one species, *L. giganteum,* has been isolated and grown in pure culture on synthetic media. Couch (1) reported that this species may be cultured as a saprophyte but is weakly parasitic on mosquito larvae, *Daphne* and copepods in nature. The species discovered by the author on dead human skin is, therefore, the first member of *Lagenidium* reported to occur saprophytically in nature. It is characterized by a coarse, extensive, richly-branched, septate mycelium, reniform zoospores, and sexually-formed oospores. Thus, its thallus is quite different from that of most species but resembles the coarse mycelium of *L. giganteum* and *L. Callinectis* Couch (2). It differs, however, from these two species by smaller zoospores and sexually-formed oospores. Accordingly, it is interpreted as a new species and named *L. humanum.**

Lagenidium humanum sp. nov. (FIGS. 1–39)

Fungus saprophyticus; thallis multicellulosis, tenuibus, ramosis, septatis, 4–20 μ diam.; sporangiis elongatis (4–7 × 15–200 μ), subsphaericis (15–30 μ), ovalibus (10–15 × 18–30 μ), oblongatis, lobatis, irregularibus vel tenuibus in unum tubulos exentibus; zoosporis reniformibus (3.5–4.5 × 7.5–8 μ); cystosporiis sphaericis (6–7.5 μ); oogonis et antheridiis elongatis (5–7 × 15–22 μ), ovalibus (10–15 × 18–25 μ), subsphaericis (10–25 μ), tenuibus, fusiformibus vel lobatis; oosporis hyalinis, laevibus, sphaericis (10–18 μ), ovalibus (8–12 × 14–17 μ) vel oblongatis; germinatione ignota.

Saprophytic in dead human skin and various synthetic media, Briarcliff, N. Y.

The zoospores of this species are reniform with a ventral groove (FIGS. 1, 2, 3) in which the two flagella appear to be inserted. The protoplasm is more or less evenly granular in appearance and includes a small oval or spherical vacuole. At the close of the motile period the zoospores round up and become cystospores (FIGS. 4, 5). These germinate within two hours (FIGS. 6, 7) without giving rise to secondary zoospores, so that *L. humanum* is monoplanetic as far as is known at present. As the germ tube elongates in the substratum, its apex enlarges (FIGS. 8, 9, 10), becomes lobed and branched (FIGS. 11, 12) and eventually develops into the thallus. The cystospore and part of the germ tube remain attached as empty structures until the thallus is well established. Thus, the vegetative development of *L. humanum* is fundamentally similar to that of other filamentous species of *Lagenidium.*

The mature thallus varies so greatly in length and diameter that it is difficult to give representative measurements and almost impossible to use vegetative characteristics for diagnostic purposes. In rare and exceptional cases it may be reduced to one cell, as in

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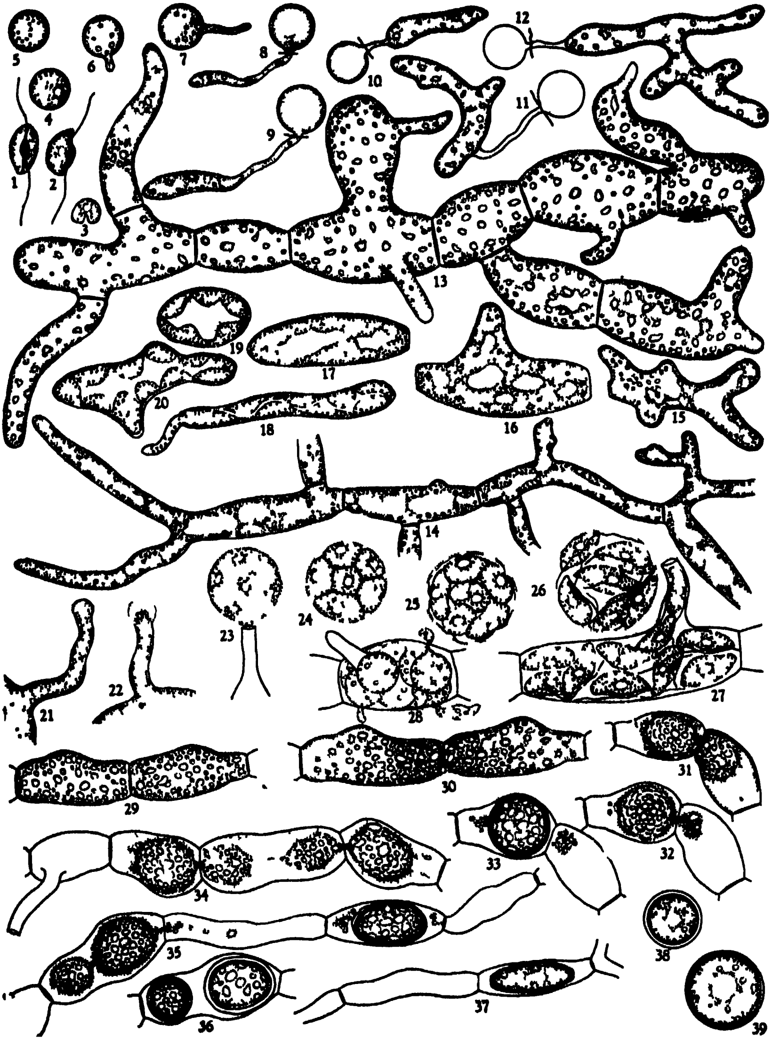
* The author is very grateful to Dr. Theodor Just of Notre Dame University for the name and Latin diagnosis of this species.



FIGS 1–39 *Lagenidium humanum*

Olpidium, whereas in most instances it is greatly extended, branched, and mycelioid like species of *Pythium.* On dead skin it is frequently composed of relatively short, oval, truncate, lobed or branched segments and is constricted at the septa as shown in fig. 13. Such thalli are often friable or fragile so that in mounting them for microscopic study the segments separate as individual cells at the septa (FIGS. 15–20). These cells may vesiculate slightly as they continue to mature, and in most cases they eventually form zoospores if conditions are favorable. On 0.5 per cent agar and in liquid media, on the other hand, the thallus is usually more filamentous with longer and narrower segments, as shown in fig. 14. Like that of other species of *Lagenidium*, the protoplasm has a pale grayish or whitish gleam and contains numerous vacuoles and bodies (FIGS. 13, 14). These bodies vary greatly in size from spherical, oval, oblong, elongate to angular in shape, but they are not as sharply refractive as the globules which occur in most chytrids.

Each segment of the sporangium is capable of becoming a sporangium and producing zoospores, but in this process they do not undergo any marked structural differentiation except the formation of an exit tube. In preparation for sporogenesis the protoplasm of the incipient sporangium undergoes the usual and well-recognized changes in appearance. The bodies begin to break up and become smaller, and the material of which they are composed becomes more highly dispersed (FIG. 15). As a result the protoplasm as a whole takes on a more uniformly grayish-granular appearance (FIG. 16). At the same time the vacuoles and their tonoplasts become more clearly-defined and conspicuous and eventually coalesce (FIG. 17) to form a large vacuole (FIGS. 18, 19, 20). By this time the exit tube has formed (FIG. 18), and it may be papillate (FIG. 20) or greatly elongate or filamentous. At this stage the tonoplast of the vacuole is usually scalloped in contour (FIG. 20), so that the sporeplasm looks as if it were undergoing centripetal cleavage. Apparently, these are not cleavage furrows, or if they are, cleavage is not completed at this stage because it usually occurs outside the sporangium.

In preparation for discharge of the sporeplasm the tip of the exit tube becomes slightly inflated (FIG. 21), deliquesces, and a globular mass of hyaline substance emerges (FIG. 22). The granular sporeplasm pushes up into this mass and expands it to the extent that it eventually consists only of a thin hyaline surrounding layer. This layer is probably transformed into the hyaline membrane which later may be seen around the zoospores (FIGS. 25, 26). The subsequent cleavage and maturation stages of the zoospores are identical to those described so well by Couch (1) for *L. giganteum* with the exception that the central vacuole is not very conspicuous (FIGS. 23, 24). If dehiscence is delayed, cleavage may occur within the sporangium (FIG. 27), so that the zoospores emerge fully formed. In rare cases the exit tube fails to deliquesce, with the result that cleavage and swarming of the zoospores may occur within the sporangium. In such instances the zoospores come to rest and form cystospores which may germinate *in situ* within two hours (FIG. 28).

The so-called oospores of *L. humanum* are formed sexually by fusion of the protoplasts of adjacent cells in the thallus. So far as is known any segment of the thallus may become an oögonium or antheridium, and these gametangia are not structurally differentiated as such. It is particularly noteworthy that the difference in size and shape exhibited by them appears to be fortuitous. The antheridium may be slightly larger than the oögonium (FIG. 37) or vice versa (FIG. 35) or they may be of similar size and shape (FIGS. 29, 30), depending on which of the segments in the thallus function as gametangia. Therefore, in the initial stages it is impossible to determine which is the antheridium or oögonium (FIG. 29). It is only after the protoplasm of one cell begins to move into the other that they may be recognized. Accordingly, recognition of the antheridium in this species is based solely on the movement of its protoplasm and not on distinctive structural characteristics. Thus, sexual reproduction in *L. humanum* may be described as isogamous or heterogamous, depending on the accidental size and shape of the respective gametangia.

Segments which are to become gametangia usually contain denser protoplasm and more bodies (FIG. 29) than ordinary vegetative cells. The first visible change in preparation for plasmogamy is a contraction of the protoplasts toward the intervening septum (FIG. 30) in much the same manner as described by the author (6) for *L. microsporum.* Some of the bodies or globules appear to coalesce, because they become larger in size and smaller in number as contraction progresses. At the same time a pore is formed in the septum, and the protoplasm of the antheridium begins to flow into the oögonium (FIGS. 31, 32). After this process has been completed the zygote rounds up and becomes enveloped by a thick, hyaline wall (FIG. 33). In a few cases observed a small part of the protoplasm of both gametangia was left behind or excluded from the zygote (FIGS. 33, 35A). Whether or not this is extraneous material resulting from a slight differentiation of gametes, and is to be interpreted as periplasm is not certain. The answer to this question must await further cytological study of fixed, sectioned and stained material.

Variations of the usual process of plasmogamy may occur in this species. In one case observed the protoplasm of a large antheridium lying between two oögonia constricted into two portions (FIG. 34), each of which later flowed into the adjacent oögonia. Thus, one antheridium is capable of fertilizing two oögonia as in species of *Olpidiopsis*. In another instance the oöplasm divided into two unequal parts (FIG. 35) during plasmogamy and eventually produced two oöspores (FIG. 39). Inasmuch as division occured before plasmogamy was completed it is not improbable that the smaller oospore is monoploid.

As the oöspores mature the globular bodies begin to break up and disperse, so that the protoplasm becomes more evenly granular (FIGS. 37–39). The oögonium wall disintegrates after a few weeks and liberates the oöspores. So far germination of the oöspores has not been observed.

SUMMARY

Lagenidium humanum was isolated on bits of dead human skin which had been floated on a watered soil sample collected in a cemetery at Briarcliff, N. Y. It was subsequently isolated from this substratum and grown in pure culture on agar and in nutrient liquid media. This species is characterized by a coarse, filamentous, mycelioid, branched and septate thallus, reniform zoospores, and sexually-formed oospores. The antheridia may be slightly larger than the oögonia or vice versa, or the two gametangia may be similar in size and shape. Accordingly, sexual reproduction in *L. humanum* may be isogamous or heterogamous.

DEPARTMENT OF BOTANY,
COLUMBIA UNIVERSITY,
NEW YORK 27, N. Y.

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DESCRIPTION OF FIGURES

FIGS. 1–39. *Lagenidium humanum*. FIGS. 1, 2, 3. Zoospores in ventral, side and median cross section views, respectively, × 1100. FIGS. 4, 5. Cystospores, × 1200. FIGS. 6, 7. Germination of cystospores on agar, × 1300. FIGS. 8, 9. Successive stages of germination of cystospores on and the enlargement of the germ tube in dead human skin, × 1300. FIGS. 10, 11, 12. Later stages of development of the thallus from the end of the germ tube; cystospore and part of germ tube persistent, × 1300. FIG. 13. Broad, septate, branched type of thallus from dead human skin, × 1100. FIG. 14. Filamentous, narrow thallus from 0.5% agar medium, × 1100. FIGS. 15–19. Successive maturation stages of separated segments into zoosporangia, × 1100. FIGS. 21, 22. Inflation and deliquescence of tip of exit tube, respectively, × 1200. FIG. 23. Naked, discharged mass of sporeplasm, × 1200. FIGS. 24, 25, 26. Cleavage and maturation stages of zoospores in a vesicle, × 1300. FIG. 27. Late dehisced sporangium with zoospores, × 1300. FIG. 28. Sporangium which failed to dehisce, cystospores germinating *in situ*, × 1300. FIG. 29. Antheridium and oogonium of similar size and shape, × 1100. FIG. 30. Late stage of same gametangia, contents contracting towards intervening septum, globules coalescing, × 1100. FIGS. 31, 32. Successive stages of isogamous plasmogamy, × 1100. FIG. 33. Same gametangia after completion of plasmogamy and formation of oospore; remnants of protoplasm in both gametangia, × 1100. FIG. 34. Large central antheridium whose content has divided into two portions, which are flowing into adjacent oogonia, × 1100. FIG. 35. Heterogamous plasmogamy; ooplasm dividing into two unequal portions during fusion, × 1100. FIG. 36. Same oogonium later with two oospores, × 1100. FIG. 37. Elongate oospore in narrow oogonium; antheridium larger than oogonium, × 1100. FIGS. 38, 39. Mature spherical oospores, × 1200.

SOME NOTEWORTHY RUSTS—II

M. J. THIRUMALACHAR

(WITH 18 FIGURES)

HEMILEIA WRIGHTIAE Racib. Paras. Alg. und Pilz. Javas, I, p. 26–27. 1900.

Hemileia Wrightiae, first described from Java by Raciborski as *Hemileiopsis Wrightiae,* has been found to occur in abundance on the leaves of *Wrightia tinctora* near Bangalore, South India. The rust is hypophyllous and can be collected in large quantities in the months of February and March. Stevens (1932), who recorded the rust in the Philippines on *Wrightia Laniti,* described what he considered to be the aecial stage of the rust, and, incidentally, for the genus *Hemileia,* for the first time. The aecia, according to him, are uredinoid, the sori appearing bright reddish in color. The aeciospores resemble the urediospores except that they possess smaller aculeate processes and that on germination they produce unbranched germ tubes. No pycnia were seen to accompany such uredinoid aecia.

In the material of the same rust collected by the writer near Bangalore on *Wrightia tinctora* large numbers of telia with viable teliospores were present and hence opportunity was taken to carry out sporidial inoculations to confirm the reported occurrence of the aecial stage of the rust by Stevens. Clusters of teliospores were easily separated with a needle from the mass of urediospores on slides under the microscope. The teliospores thus separated were used for inoculating young leaves of *Wrightia tinctora.* The inoculated plants were inclosed in moist chambers for 48 hours after which they were transferred to the greenhouse for observation. The teliospores readily germinate within five hours, developing numerous sporidia. No signs of infection appeared, even after a lapse of twenty days, and all inoculation experiments have given negative results. This supports the view that *H. Wrightiae* is not an autoecious rust with an aecial stage on the same host, as considered by Stevens. The spore form described by Stevens as aecia might be only uredia.

Hemileia mysorensis Thirumalachar & Gopalakrishnan sp. nov.

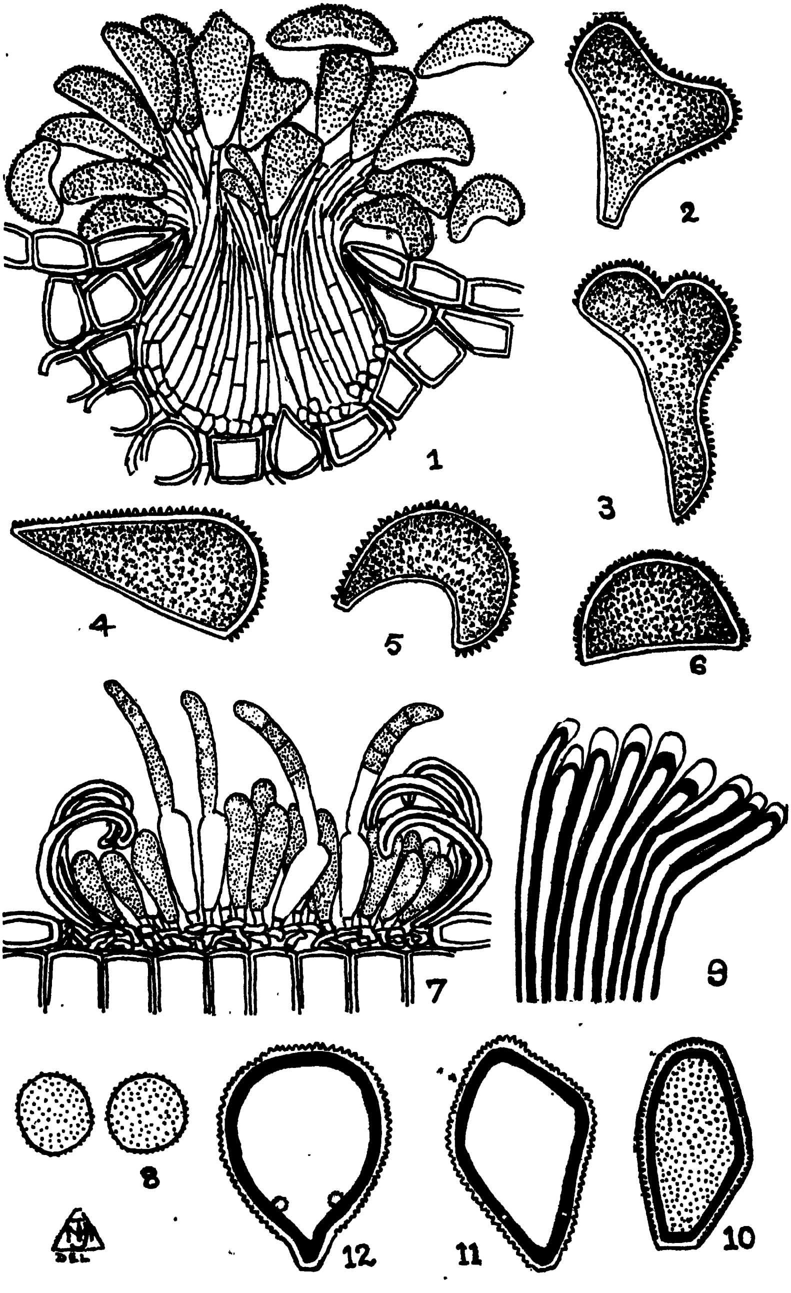
Infectionis maculae indistinctae. Uredia minuta, hypophylla, raro amphigena, sparsissima, citreo-lutea, pulverulenta. Sori superstomales, constantes ex massa hypharum fasciculatarum quae bene evolvuntur in substomali spatio, sed in sporas non mutantur quaeque ex stomate emergunt atque acervatas sporas producunt sporogenis sporophoris insidentes. Urediosporae bilateraliter symmetricae, citreo-luteae, triangulares vel reniformes 30–45 × 19–25 μ, in superficie convexa acutatis processibus opertae leves in superficie plana.

Hab. in foliis *Gymnema* sp. indet. (Asclepiadaceae), Balehonnur, Mysore, South India, leg. K. S. Gopalakrishnan, 12–4–1946. Typus positus in Herb. Crypt. Ind. Orient., New Delhi, in Arthur Herb., Purdue Univ., Lafayette, Indiana, U. S. A., in Herb. I. M. I., Kew, in Anglia.

Infection spots indistinct. Uredia minute, hypophyllous, rarely amphigenous, very sparse, orange-yellow, pulverulent; sori superstomal, composed of a well developed mass of fasciculate hyphae in the substomal space without getting transformed into spores, emerging out of the stoma and bearing clusters of spores on sporogenous sporophores. Urediospores bilaterally symmetrical, orange-yellow, triangular to reniform in shape, 30–45 × 19–25 μ, covered with aculeate processes on the convex surface and smooth on the flat side.

The rust is foliicolous and occurs as tiny yellow specks. It can be detected only with difficulty amidst the sooty blotches of a Perisporiaceous fungus which occurs on the same host. Microtome sections through the sori indicate that the mycelium within the host is very coarse, and prior to the formation of the sorus (FIG. 1) large strands of fasciculate hyphae are grouped beneath the stoma and are up to 70–100 μ in diam. The guard cells become distended to such a great extent that the superstomal nature of the sorus in later stages becomes obscure, and appears like a subepidermal sorus with ruptured epidermis. The urediospores (FIGS. 2–6) are of various shapes but conform to the usual types met with in species of *Hemileia*.

Three species of *Hemileia* are known to occur on the members of the Asclepiadaceae, all of them being recorded from Africa. *Hemileia sonensis* Syd. (Sydow 1914), described on an unidenti-



FIGS. 1–12. Noteworthy rusts.

fied member of the Asclepiadaceae, has urediospores measuring 22–32 × 18–25 μ, teliospores are unknown. *Hemileia Chlorocodonis* Syd., recorded on *Chlorocodon Wightii* (Sydow, H. & P. 1913), has urediospores measuring 18–24 × 14–18 μ, whereas the urediospores of *H. scitula* Syd. (Sydow 1937), on *Periploca* sp., measure 20–28 × 19–25 μ. From this it is clear that *Hemileia mysorensis* can be easily distinguished from all of these because of larger spores.

Mainsia Pterocarpi Thirumalachar sp. nov.

Uredia hypophylla raro amphigena, in infectionis maculis indistinctis, pallidis; intraepidermalia, lutea, erumpentis atque pulverulenta. Urediosporae subglobosae vel sphaericae, pallide luteae, singulis pediculis insidentes atque haud acervatae, 12.5–15 × 10–12.5 μ, episporio tenui, hyalino, minute atque dense echinulato. Telia minuta, evolventia ut crustae cereae atque urediis interspersa, intraepidermalia atque erumpentia, paraphysata, paraphysibus marginalibus atque incurvis; teliosporae hyalinae, pedicellatae, 4–6 sporis aggregatis super cellulam basalem sporogenam, cylindricae, in apice latiores quam in basi utroque apice rotundatae, germinantes per elongationem apicis sporarum in 4-cellulatum promycelium; 21–30 × 10–12.5 μ, episporium tenue hyalinum, leve.

Hab. in foliis *Pterocarpi marsupii,* Roxb. Balehonnur, Mysore, South India, 18–4–1942, leg. M. J. Thirumalachar. Typus lectus in Herb. Crypt. Ind. Orient., New Delhi, Arthur Herb., U. S. A, in Herb. I. M. I., Kew, Anglia.

Uredia hypophyllous rarely amphigenous, on pale indistinct infection spots, intraepidermal, yellow, erumpent and pulverulent; urediospores subglobose to spherical, pale yellow, borne singly on pedicels and not clustered, 12.5–15 × 10–12.5 μ. Telia minute, developed as waxy crusts and interspersed with uredia, intraepidermal and erumpent; paraphysate, paraphyses marginal and incurved; teliospores hyaline, one-celled, pedicellate, 4–6 spores in a cluster on a sporogenous basal cell, clavate to cylindric, broader at the apex than at the base, rounded at both ends, germinating by the prolongation of the spore apex into a four-celled promycelium, 21–30 × 10–12.5 μ; epispore thin, hyaline, smooth. Pedicel hyaline, deciduous.

Pterocarpus marsupium is an important timber tree in the forests of Mysore. The rust is foliicolous, and when present in abundance, causes severe defoliation of the shoots. Only uredia and telia, both of which are intraepidermal in origin, are known. There is no germ pore for the extrusion of the promycelium. The teliospores of this rust resemble those in species of *Maravalia,* which includes several species like *M. pallida* Arth. & Thaxt., *M. achroa* (Syd.) Arth. & Cumm. on members of the Leguminosae. The telia are surrounded by a basket of paraphyses which are hyaline, marginal, incurved and possess a central hyaline core.

The genus *Mainsia* was established by Jackson (1931) to accommodate those rust species on *Rubus* which were characterized by the possession of one-celled hyaline pedicellate teliospores and which were originally included under *Spirechina.* This change was necessitated by the discovery that the type of *Spirechina, S. Loesneriana* (P. Henn.) Arth. was a species of *Kuehneola* having short chains of teliospores. Jackson further pointed out that the pycnia, aecia, uredia and telia are all intraepidermal, a distinguishing feature which separates it from the genus *Maravalia.* All the species of *Mainsia* so far recorded occur on *Rubus,* and because of this the conclusion has been drawn that the genus is limited to *Rubus.* The rust on *Pterocarpus marsupium* has uredia and telia developed in intraepidermal sori, with the teliospores resembling in structure and germination those of other species of *Mainsia.* The only point of contention against the inclusion of this rust under *Mainsia* might be that it parasitizes a member of the Leguminosae. It is true that certain rust genera like *Phragmidium* are solely restricted to members of the Rosaceae. However, many others like *Ravenelia,* which were originally considered to parasitize hosts belonging only to the families Euphorbiaceae and Leguminosae, have now been shown to occur on Tiliaceae also. The writer, therefore, considering the structure and development of the spore forms, is inclined to believe that the rust under consideration may be properly regarded as a species of *Mainsia.* Paraphyses have been recorded for some of the species of *Mainsia* also, like *M. Lagerheimii* (P. Magn.) Jackson & Holway.

Corbulopsora Cumminsii Thirumalachar **sp.** nov.

Uredia hypophylla, subepidermalia, minuta, citreo-lutea, paraphysata erumpentia atque pulverulenta, circumdata peridii vallo composito ex vallaribus cellulis quae lateraliter sunt unitae, in apice liberae, magnitudinis 105–112 × 6–10 μ, foramine in apice relicto ad liberationem sporarum; peridii cellulae crassis parietibus praeditae, in apice incrassatae. Urediosporae ovato-ellip-

soideae vel cylindricae, 25–36 × 14–21 μ, intus contentis citroluteis; episporium hyalinum, 3.5–5 μ crassum, dense foveolata; germinationis pori indistincti; paraphyses sporis associatae, tenuiter incurvatae, magnitudinis 40 × 4 μ. Teliosporae visae tantum in urediis veteribus, unicellulatae, pedicellatae, luteo-brunneae, oblongae, cylindricae, in apice rotundatae, leves, magnitudinis 30–40 × 14–22 μ.

Hab. in foliis *Lactucae runcinatae* DC. Hebbal, Bangalore, South India, 15–12–1944, leg. M. J. Thirumalachar. Typus positus in Herb. Crypt. Ind. Orient., New Delhi, Arthur Herb., U. S. A., in Herb. I. M. I., Kew, Anglia.

Uredia hypophyllous, subepidermal, minute, orange-yellow, paraphysate, erumpent and pulverulent, surrounded by a stockade of peridium composed of slender palisade-like cells which are united laterally and measure 105–112 × 6–10 μ leaving an aperture at the apex for the escape of the spores, cells of the peridium thick-walled and swollen at the tip. Urediospores ovate-ellipsoid to cylindric, 25–36 × 14–21 μ, with orange-yellow contents, membrane hyaline, 3.5–5 μ thick, deeply pitted, germ pores indistinct; paraphyses associated with the spores, slightly incurved, measuring 40 × 4 μ. Teliospores observed only within old uredia, one-celled, pedicellate, yellowish-brown, oblong-cylindrical. rounded at the apex, smooth, 30–40 × 14–22 μ.

The rust parasitizes the leaves of *Lactuca runcinata* forming pinkish-red infection spots. The uredia are subepidermal and the urediospores are borne singly on pedicels. The rust occurs all year in the uredial stage. Teliospores have been observed in very few cases and then only within old uredia. The stockade of palisade-like peridial cells (FIG. 9) around the telia and uredia, if present, is a distinguishing character of the genus. The two species of *Corbulopsora* described by Cummins (**1940**) from New Guinea occur on *Olearia*, a member of the Compositae. The present rust, which is also on a member of the Compositae, differs in spore measurements from the New Guinea species. The name *Corbulopsora Cumminsii* is proposed in honor of Dr. G. B. Cummins of Purdue University, U. S. A.

SCOPELLA FICI Mundkur & Thirumalachar. Occas. paper No. 16, I. M. I., England, p. 1–27. 1946.

A rust on *Ficus* sp. collected by the writer has recently been described by Mundkur and Thirumalachar (**1946**) as *Scopella Fici*. Only pycnia and telia were present in the type material.

The telial initials immediately follow the pycnia in development. The pycnia are subcuticular and the telia arise in orange-yellow waxy crusts bearing clusters of teliospores on sporogenous basal cells. Collections of the rust on the same host plant in different seasons revealed the presence of an uredial stage. Collections made in the months of February and March contained large numbers of uredia following the pycnia; the telia appear at a much later period. The development of a few teliospores within old uredia confirmed the genetic relationship of the spore forms. The development of either uredia or telia following the formation of pycnia indicates that *Scopella Fici* is one of the unstable rust forms with short-cycling tendencies, and adds another instance to those already described in detail by Jackson (**1931a**). *Scopella Fici* is therefore a brachy-form with subepidermal erumpent uredia, with urediospores developed in clusters of 8–16 on sporogenous basal cells. Mature spores are chocolate-brown, obovate-ellipsoid to pyriform (FIGS. 11–12), 31–45 × 25–35 μ, with two distinct germ pores at the base above the hilum. The wall is bilaminate; the inner one is smooth and golden-brown and the outer one is hyaline and shows echinulations.

Cerotelium Wagateae Thirumalachar & Gopalakrishnan, sp. nov.

Pycnia atque aecia ignota. Uredia minuta, hypophylla, dispersa, tenuiter brunnea, subepidermalia, erumpentia, hyphoides paraphysibus intus ad muros dispositis. Urediosporae sessiles, obovatae vel ellipsoideae, luteo-brunneae, tribus quattuorve germinationis poris instructae, magnitudinis 19–27 × 15–20 μ. Telia subepidermalia, minuta, urediis associata, initio lenticularia, postea erumpentia; teliosporae catenatae, lateraliter coalescentes, columnam in basi efformantes, in apice separatae atque pulverulentae atque in maturitate germinantes; sporae 4–6 in singulis catenis, sphericae vel angulariter globoideae, hyalinae, tenuiter parietatae, leves, magnitudinis 12–19 × 8–12 μ.

Hab. in foliis *Wagateae spicatae* Dalz., Balehonnur, Mysore, South India, 29–4–1945, leg. M. J. Thirumalachar (**Typus**), 12–3–1944 leg. K. S. Gopalakrishnan. Typus positus in Herb. Crypt. Ind. Orient., New Delhi, Arthur Herb., U. S. A., in Herb. I. M. I., Kew, Anglia (FIGS. 13–14).

Pycnia and aecia unknown. Uredia minute, hypophyllous, scattered, pale brown, subepidermal, erumpent, lined with hyphoid paraphyses. Urediospores sessile, obovate to ellipsoid, yellowish-brown, with three to four germ pores and measuring 19–27 × 15–20 μ. Telia subepidermal, minute, associated with uredia, lenticular in early stages, later on becoming erumpent; teliospores in chains showing lateral coalescence, forming a column at the base and becoming separated and pulverulent at the apex, 4–6 spores in a chain, spherical to angularly globoid, hyaline, thin-walled, smooth, 12–19 × 8–12 μ, germinating at maturity.

The leaf rust on *Wagatea spicata,* a member of the Leguminosae, has on examination proved to be an undescribed species of *Cerotelium.* It differs from *Cerotelium morobeanum* Cummins on *Derris* sp. (Cummins **1941**) and other species on Leguminosae in the size of the spores. The rust pustules are very minute and can hardly be seen in the field. No other species of *Cerotelium* on Leguminosae has so far been recorded from India.

PUCCINIA BOTTOMLEYAE Doidge. Bothalia 3: 498. 1939.

Hab. on the leaves and inflorescence of *Aristida depressa* Retz., Hebbal, Bangalore, South India, 2–3–1945, leg. M. J. Thirumalachar.

Aristida depressa is a common weed grass in the dry farm lands of Bangalore. The rust attacks the leaves and the inflorescence forming characteristic pulvinate black sori. The uredia are epiphyllous and also distributed on the inflorescence. They are covered by the epidermis in the early stages. The urediospores are subglobose to spherical, cinnamon-brown and measure 21–28 × 20–24 μ; the epispore is hyaline, 2 μ thick, and densely verruculose. There are 8–11 scattered germ pores. The telia are at first covered over by the epidermis but later become naked and pulvinate, appearing as black crusts up to 1 mm. long. The teliospores are ovate to subglobose and rounded at both ends, chestnut-brown, smooth and measure 30–35 × 20–25 μ. The spores are not constricted at the septa and the walls are thick with the apex thickened up to 6 μ. The pedicels are up to 125 μ long, hyaline, persistent, and sometimes obliquely inserted. The telia possess numerous capitate, hyaline to fuscous paraphyses which measure about 112 μ long and 20 μ at the bulged capitate portion.

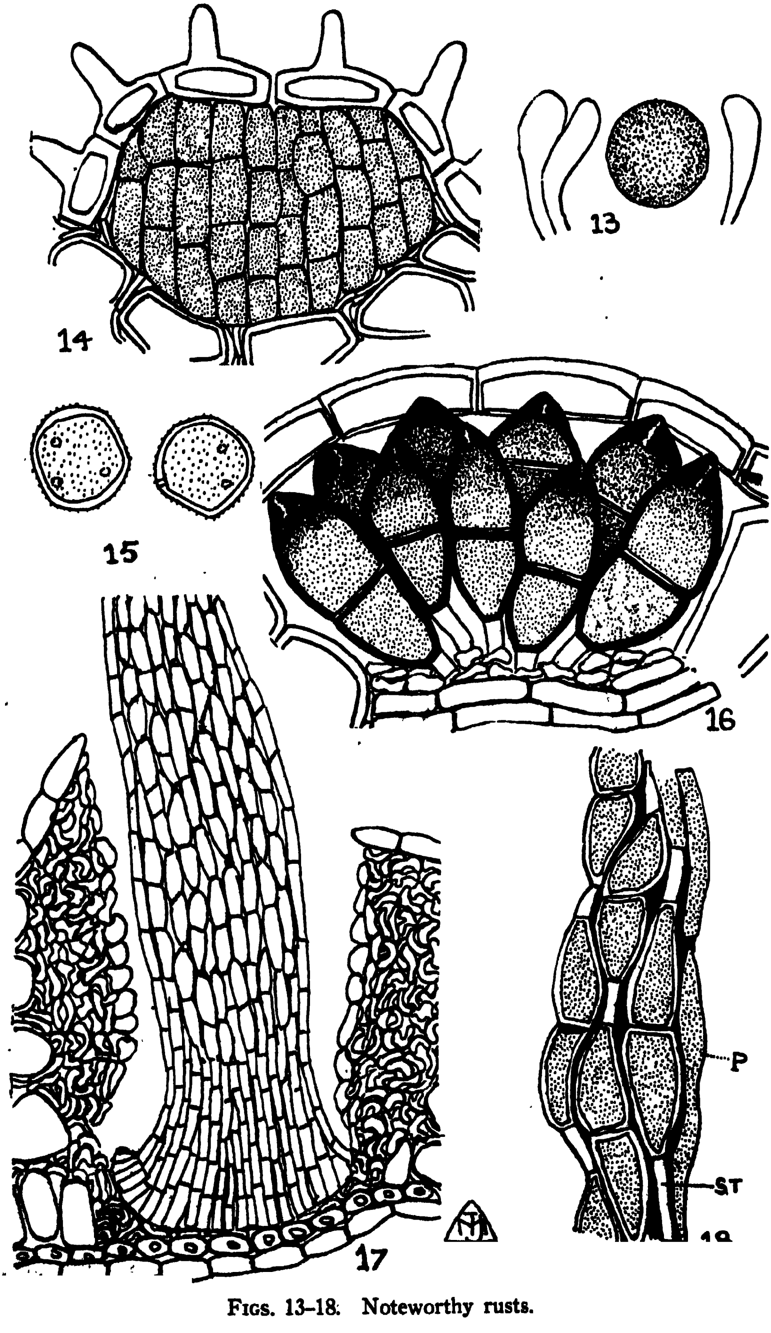
The crustose pulvinate nature of the telia distributed on the inflorescence immediately brings to mind that the rust might be closely related to *P. Eylesii* described by Doidge from South

Africa (1926). *Puccinia Aristidicola* which is known to occur in India is clearly a distinct rust possessing striate sori. The present rust differs from *P. Eylesii* in having a paraphysate telium and much broader urediospores. On the other hand, it resembles very closely *Puccinia Bottomleyae* described by Doidge (1939) from South Africa on *Aristida adscensionis, A. Welwitschiae* and *A. barbicollis*. The urediospores of this rust measure 22–30 × 20–25 μ and thus compare favorably with 21–28 × 20–24 μ in the material collected by the writer. The germ pores are stated by Doidge to be scattered and from 4 to 7 for the South African collections, whereas they are up to 11 in the collections made by the writer. In the size, shape and structure of the teliospores and in possessing capitate paraphyses the rust on *Aristida depressa* closely resembles *P. Bottomleyae* and there is very little doubt that the two belong to a single species.

A morphological study of the sorus indicated that the telia are subepidermal and deep-seated within the host tissue. The teliospores are developed in clusters on indistinct sporogenous basal cells which are laterally free and firmly fixed to the basal hymenium. Consequently, when the spores are scraped from the spore bed, the clusters of teliospores are carried over along with the mutilated basal sporogenous cell. There are 8–10 teliospores in a cluster, the spores being of different maturity. Such clustered teliospores have been demonstrated in *Puccinia Solmsii* by the writer (1945) and Kuhnholtz-Lordat (1944) described them in a number of species of *Puccinia* like *P. Cynodontis, P. Polygonii,* and others. This clustered nature by itself may not have generic significance but only indicates one of the modes of development (fasciculate) as described by Kuhnholtz-Lordat.

Puccinia Bulbostylidicola Thirumalachar sp. nov.

Uredia hypophylla, distributa super pedunculos, linearia vel elliptica, 1–2 mm. longa, subepidermalia, erumpentia atque pulverulenta, brunnea, in statu initiali cooperata epidermate; urediosporae subglobosae vel ellipsoideae, 18–21 × 11–19 μ, tenuiter parietatae (1–1.5 μ), in apice haud incrassate minute verruculosae, tribus dispersis germinationis poris. Teliaurediis similia, distributa per pedunculos, nigra, haud erumpentia; teliosporae ellipsoideae vel cylindricae, luteo-brunneae, colore aliquantulum profundiore in apice, tenuiter constrictae ad septa; lateralibus angularibus ob mutuam compressionem in



FIGS. 13–18. Noteworthy rusts.

soro ipso, leves, 31–55 × 14–23 μ, in apice incrassatae ad 6 μ. Mesosporae plures, magnitudinis 25–35 × 12–20 μ. Pediculis hyalinis, persistentibus, 25–30 μ longis.

Hab. in foliis et pedunculis *Bulbostylidis barbatae* Kunth., Hebbal, Bangalore, South India, 8–1–1945, leg. M. J. Thirumalachar. Typus positus in Herb. Crypt. Ind. Orient., New Delhi, Arthur Herb., U. S. A., in Herb. I. M. I., Kew, Anglia (FIGS. 15–16).

Uredia hypophyllous, distributed on the peduncles, linear to elliptic, 1 to 2 mm. long, subepidermal, erumpent and pulverulent, chocolate-brown, covered by the epidermis in the early stages; urediospores subglobose to ellipsoid, 18–21 × 11–19 μ, thin walled (1–1.5 μ), not thickened at the apex, minutely verruculose, with three scattered germ pores. Telia similar to uredia, distributed on the peduncles, black, non-erumpent, teliospores ellipsoid to cylindric, yellowish-brown, with a deeper shade towards the apex, slightly constricted at the septa, sides angular on account of mutual compression within the sorus, smooth, 31–55 × 14–23 μ, thickened at the apex up to 6 μ. Mesospores numerous, measuring 25–35 × 12–20 μ. Pedicels hyaline, persistent, up to 25–30 μ long.

When the first collections of the rust were made, only telia were present in large numbers. A comparative study indicated that the telia of the rust closely resembled *P. Bulbostylidis* Doidge recorded by Doidge (1926) from South Africa on *Bulbostylis Burchelli.* The teliospores in this rust measure 33–60 × 13–19 μ and thus compare very favorably with 31–55 × 14–23 μ, which denotes the size of the teliospores in the rust under study. But the urediospores in the two rusts show characteristic differences. In *P. Bulbostylidis* according to Doidge, they are golden-brown and measure 16–20 × 21–28 μ and therefore are very much broader than those of the present rust in which they are only 18–21 × 11–19 μ. Further, the spores are thick-walled (3–3.5 μ) with three equatorial germ pores in *P. Bulbostylidis,* whereas they are much thinner (1.5 μ) in the present rust, the germ pores being scattered and not equatorial. The two rusts can therefore be differentiated by the structure and size of the urediospores.

PUCCINIA EXHAURIENS Thüm. Flora **1876**, p. 425, Sydow Monogr. Ured. I, p. 344.

On the leaves of *Jasminum* sp., Nalur, Thirthahalli, Mysore, 4–4–1945, leg. M. J. Thirumalachar, Balehonnur, Mysore, 15–6–1945, leg. K. S. Gopalakrishnan.

This rust is known to occur on *Jasminum tortuosum* in South Africa. A detailed study of it has indicated that it is a microcyclic rust consistently lacking pycnia.

PUCCINIA OAHUENSIS E. & E. Bull. Torrey Club **22**: 435. 1895. (*Uredo Digitariaecola* Thüm. Myc. Univ. No. 2041, 1882; *Puccinia Digitariae* Pole Evans. Ann. Bolus Herb. **2**: 111. 1917.)

On the leaves of *Digitaria marginata* Link. Hebbal, Bangalore, 19–1–1945, leg. M. J. Thirumalachar. The rust was described by Pole Evans from South Africa as *P. Digitariae* and was known by that name until recently when Cummins (**1943**) pointed out that *Puccinia oahuensis,* described by Ellis and Everhart in 1895, is the same rust and thereby reduced *P. Digitariae* to synonymy. Though this rust has not been recorded for India by Butler and Bisby (**1931**) or Mundkur (**1938**), a collection was made in India and distributed in Sydow Ured. 2272, which is quoted by Cummins (**1943**). An account of the measurements of the urediospores and teliospores based upon numerous collections is given by Cummins and those of the rust collected by the writer on *Digitaria marginata* agree with them in all respects. The measurements obtained by the writer are II: 25–31 × 20–25 μ; and III: 35–50 × 20–27 μ. The urediospores possess three to four scattered germ pores and not equatorial ones as described for *P. oahuensis*. Such a feature has been noticed by Cummins also in a collection of the rust on *D. scalarum* made by Hansford in Uganda and Cummins considers that it may only be a variant of *P. oahuensis.*

PUCCINIA PHYLLOCLADIAE Cke. *in* Grevillea **10**: 125. 1882. Syd. Monogr. Ured. I, 612. Doidge, Bothalia **2**: 111–112. 1926.

On the cladodes of *Asparagus* sp., Korekote, Thirthahalli, Mysore, 4–4–1945, leg. M. J. Thirumalachar, Balehonnur, Mysore, South India, 15–6–1945, leg. K. S. Gopalakrishnan.

A rust parasitizing the cladodes of *Asparagus* in Mysore compared very favorably with *Puccinia Phyllocladiae* Cke. which is known to occur in South Africa on *Asparagus falcatus.* The telia are amphigenous, subepidermal and form dull brown sori. The teliospores are broadly ovate, yellowish-brown, not constricted at the septa and measure 34–42 × 25–35 µ. The measurement given by Doidge for the South African collections is 32–45 × 30–40 µ. The pedicels are often obliquely inserted and the germ pore in the upper cell is not apical but is shifted to one side. In all these essential features the rust on *Asparagus* collected by the writer resembles the descriptions of *P. Phyllocladiae* given by Doidge (1926).

Although no spore form other than telia is known for the rust, abundant uredia are present in the writer's collection. These are developed early in the season and are replaced by telia later on. They are borne on the same mycelium as the telia. The association of some urediospores within some telia confirms beyond doubt the genetic relationship between the two spore forms. The uredia are amphigenous, subepidermal, erumpent and pulverulent, chocolate-brown and associated with a few clavate paraphyses. Urediospores are pedicellate, ovate-ellipsoid to obovate, golden-yellow with a brownish tinge, have 5–6 equatorial germ pores and measure 26–38 × 19–22 µ. The epispore is thin-walled and densely verruculose. The spores readily germinate when placed in moist chambers, and develop long germ tubes.

PUCCINIA SHIRAIANA Syd. Hedwigia **1899**, p. 141. Sydow Monogr. Ured. I, 232.

Hab. on the leaves and petioles of *Justicia* sp., Balehonnur, Mysore, South India, 29–4–1945, leg. M. J. Thirumalachar, Lakkavalli, Mysore, 14–10–1945, leg. Thirumalachar. The rust collected on *Justicia* (*tomentosa?*) has only telia, hypophyllous and often distributed on the petioles as black crusts. *Puccinia peraffinis* Syd. on *Justicia diffusa* and *Puccinia Thwaitesii* B. & Br. on *J. gendurosa* also occur in Mysore and these are autoecious species. Sydow and Petrak (**1931**) record this rust from the Philippines on *J. procumbens*.

STRUCTURE OF THE TELIUM IN GAMBLEOLA CORNUTA MASSEE

Gambleola cornuta is a monotypic genus producing long blackish spore tendrils on the leaves of *Berberis nepalensis*. The type of the genus was collected by Dr. Gamble near Chakrata, Upper India and is found to be well distributed on the hill tops. In an account of the evolutionary tendencies and the origin of the life-cycles in rusts, Jackson (1931) gives a vivid account of the derivation of microcyclic rusts like *Didymopsora, Gambleola, Pucciniosira* and others from *Endophyllum*-like forms, possibly by the lateral coalescence of the spore chains. He cites as evidence the presence of the peridium in the telium of *Pucciniosira* and *Gambleola,* and the occurrence of distinct sterile intercalary cells between the fertile spores in all these genera. These morphological features (*i.e.,* the presence of a peridium and sterile intercalary cells), Jackson points out, do not appear to have been noted in this genus previously. However, it might be pointed out that the presence of an outermost layer of sterile cells (though not termed as the peridium) binding the spore chains is described in the telial column of *Gambleola* (Dietel 1928).

Large quantities of the material of *G. cornuta* were collected by the writer in the Kodiakanal Hills, South India. This made possible a detailed morphological study which adds further confirmatory evidence to Jackson's findings. Although a pycnial stage for the rust is described for the genus by Massee, no pycnia were seen to accompany the telia in my material. The telial initials are organized beneath the epidermis by the formation of a plectenchyma composed of coarse hyphal strands. A palisade layer of basal cells is differentiated. These cells abstrict, in succession, a large number of rectangular, thin-walled, spore mother cells which coalesce laterally to form a columnar structure. As the development of the spore column is towards the lower epidermis, the sorus appears cupulate and deep-seated, bordered by globoid hyphal cells, which however do not become papillate as in *Masseeella* (FIG. 17). Each spore mother cell cuts off an intercalary cell and a teliospore initial which becomes two-celled and *Puccinia*-like, following one more division. The outermost layer of spore mother cells remains one-celled and constitutes the peridium (FIG. 18). On account of the lateral adherence of the spore chains, long spore columns are produced. The sterile intercalary cells do not function as disjunctor cells, but only serve to point out the relationships of microcyclic rusts like *Gambleola* with *Endophyllum*-like forms.

PHAKOPSORA TECTA Jackson & Holway, Mycologia **18**: 148–149, 1926.

Hab. on the leaves of *Commelina* sp., Bangalore, South India, 22–12–1944, leg. M. J. Thirumalachar. Jackson and Holway (**1926**) described *Phakopsora tecta* on *Commelina quitensis* from Bolivia, South America. Petrak and Ciferri (**1932**) recorded it for the Dominican Republic. Although species of *Uromyces* are present in India on members of the Commelinaceae, *Phakopsora tecta* is being reported only from the present collection as it was not included in a recent review of the genus *Phakopsora* by Mundkur (**1943**). The uredia are characteristically different from those of other rusts on *Commelina* in that they possess a membranous peridium formed by the union of bases of incurved capitate paraphyses. A small pore is formed at the apex for the escape of the spores. The urediospores are hyaline, ovate-ellipsoid, and finely verruculose to echinulate. The infestation of *Phyllosticta Uredinicola* brings about the deterioration of the spores and the ultimate collapse of the sorus. Unlike some other uredinicolous fungi, *Phyllosticta Uredinicola* develops within the centre of the sorus and arrests further development of the spores.

Aecidium Memecyli Thirumalachar sp. nov.

Infectionem systemican novorum surculorum causat. Pycnia amphigena, melleo-lutea, parva, subepidermalia, applanata, ostiolata, paraphysibus ostiolaribus. Aecia subepidermalia, erumpentia, pulverulentia, cupulata, alba, peridiis bene evolutis; peridii cellulae globosae vel angulares, crassis parietibus praeditae in lateribus conterminis, striatae, magnitudinis 18–31 × 15–20 μ. Aeciosporae angulariter globoideae ob compressionem, hyalinae, tenuiter parietatae, minute atque dense verruculosae, magnitudinis 19–24 × 14–21 μ.

Hab. in *Memecyli* specie (*umbellati?*), Nandi Hills, Mysore, South India, 15–7–1945, leg. H. C. Govindu. Typus lectus in Herb. Crypt. Ind., Orient., New Delhi, Arthur Herb., U. S. A., in Herb. I. M. I., Kew, Anglia.

Causing the systemic infection of the young shoots; pycnia amphigenous, honey-yellow, small, subepidermal, applanate, ostiolate with ostiolar paraphyses. Aecia subepidermal, erumpent and pulverulent, cupulate, white, with well developed peridia; peridial cells angular to globoid, thick-walled on the abutting sides, striate, 18–31 × 15–20 μ; aeciospores angularly globoid due to compression, hyaline, thin-walled, minute and densely verruculose, measuring 19–24 × 14–21 μ.

The rust causes systemic infection of the young shoots developing in the axils. As these unfold, a malformed witches'-broom-like structure completely studded with pycnia and later on by aecia is formed. The rust differs from any of the other *Aecidium* and aecial stages of rusts recorded on the members of the Melastomaceae.

UREDO CELASTRI Arthur & Cummins, Philippine Jour. Sci. **61**: 463–488, 1936.

Hab. on the leaves of *Celastrus paniculata* Willd., Nandi Hills, Mysore, South India, 29–4–1945, leg. M J. Thirumalachar.

A rust on *Celastrus paniculata* Willd. was collected by the writer in Nandi Hills which appeared to be identical with *Uredo Celastri* described by Arthur and Cummins (**1936**) from the Philippines. The rust is hypophyllous, minute, golden-yellow when fresh and turning yellowish-brown on drying up. The uredia are subepidermal, erumpent and paraphysate; the urediospores ovate-ellipsoid, cinnamon-yellow and distinctly echinulate. There are 5 or rarely 6 scattered germ pores. The complete absence of any peridium indicates that the rust is not congeneric with *Pucciniastrum Celastri* Syd. described by Sydow and Butler (**1907**) on *Celastrus* from the Himalayas. The urediospores, in the material collected by the writer, measure 22–26 × 22–30 μ and are therefore slightly narrower than the measurements given by Arthur and Cummins for *U. Celastri* (22–27 × 28–34 μ). But for this minor variation, the present rust agrees with *U. Celastri.*

UREDO CHASALIAE Petch, Ann. Roy. Bot. Gard. Peradeniya iv, pt. v, p. 303, 1909. Sacc. Syll. Fung. **21**: 798.

Hab. on the leaves of *Chasalia curviflora* Thw., Balehonnur, Mysore, South India, 28–4–1945, leg. M. J. Thirumalachar, leg. K. S. Gopalakrishnan, 12–2–1945. The rust was described by Petch in Ceylon on the same host species.

UREDO OPHIORRHIZAE Petch. Ann. Roy. Bot. Gard. Peradeniya, vi: 212, 218, 1917. Sacc. Syll. Fung. **23**: 945.

Hab. on the leaves of *Ophiorrhiza Brunonis* W. & A., Kemmangundi, Mysore, South India, 10–8–1945, leg. H. C. Govindu, and Balehonnur, Mysore, 12–1–1946, leg. K. S. Gopalakrishnan.

In conclusion, the writer wishes to acknowledge his deep sense of gratitude to Dr. G. B. Cummins, Purdue University, Lafayette, Ind., U.S.A., for the benefit of many valuable suggestions, and to Dr. L. N. Rao, Central College, Bangalore, for kind encouragement. Grateful thanks are due to Rev. Dr. H. Santapau, Ph.D., S. J., Professor of Botany, St. Xavier's college, Bombay, for kindly translating to Latin the diagnoses of the new species.

UNIVERSITY OF WISCONSIN,
MADISON, WISCONSIN.

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EXPLANATION OF FIGURES

FIG. 1: Uredium of *Hemileia mysorensis*, × 300. FIGS. 2–6: Urediospores of *H. mysorensis*, × 900. FIG. 7: Telium with germinating teliospores of *Mainsia Pterocarpi*, × 400. FIG. 8: Urediospores of *M. Pterocarpi*, × 800. FIG. 9: Portion of the peridium of *Corbulopsora Cumminsii*, × 450. FIG. 10: Urediospore of *C. Cumminsii* showing the pitted wall, × 900. FIGS. 11–12: Urediospores of *Scopella Fici*, × 900. FIG. 13: Urediospore and the portion of the hyphoid paraphyses of *Cerotelium Wagateae*, × 900. FIG. 14: Telium of *C. Wagateae*, × 400. FIG. 15: Urediospores of *Puccinia Bulbostylidicola*, × 800. FIG. 16: Telium of *P. Bulbostylidicola*, × 800. FIG. 17: Section through the telium of *Gambleola cornuta*, × 200. FIG. 18: Portion of the telial column enlarged showing 'P' = peridium and 'St' = sterile intercalary cell, × 900.

NOTES AND BRIEF ARTICLES

LOHWAG'S ANATOMIE DER ASCO- UND BASIDIOMYCETEN

It seems desirable to call attention to an authoritative and exhaustive work by the late Professor H. Lohwag, of the University of Vienna, entitled *Anatomie der Asco- und Basidiomyceten,* published in 1941 shortly before this country was drawn into war. Very few copies reached the United States and since the publisher was Borntraeger Bros. of Berlin it is reasonable to suppose that the publisher's stock has been destroyed. This work covers 529 pages of text with the addition of an extensive list of literature of more than 900 titles reviewed by the author and covering the period between 1601 and 1940. The 348 text figures add greatly to the value of the book. An index of more than 600 terms increases the current mycological vocabulary as found in Snell's *Three Thousand Mycological Terms.* It was issued as Band VI, Abteilung II, Teilband 3, C of the general series entitled *Handbuch der Pflanzen[illegible]mie* under the editorship of the late Prof. K. Linsbauer. It [illegible] be noted in passing that presumably reliable reports are to the effect that Prof. Lohwag died of starvation in Vienna shortly after the end of the war in Europe.

The book is divided into twelve chapters based upon the Haberlandt system of physiological plant anatomy. Certain types of hyphae figure prominently in more than one of these chapters indicating the several types of anatomic function one hypha can have during its development from initiation in mycelium or fructification to maturity. A large mass of data has been brought together, much of it substantiated by only one description, one report, one experiment, or one histological study. Frequently throughout the work it is pointed out that additional research on certain topics may or will change the concept of discussed anatomic or physiologic-anatomic functions. Also, it is frequently evident that the author is treading, or regards himself as treading, on thin ice in respect to his knowledge of certain structures, and in respect to his interpretation of the knowledge of others concerning those or other structures. The book poses many problems for solution in the future by mycologists interested in anatomy, physiology or physiological anatomy. Although most of the book centers around the role played by individual hyphae in the mycelium or fructification, specific discussions of such structures as rhizomorphs, as found in *Armillaria, Merulius* and other basidiomycetous as well as ascomycetous fungi, and sclerotia, as found in *Typhula, Sclerotinia* and other basidiomycetous and ascomycetous fungi, are most interesting and present many problems.

An excellent translation has been made of Lohwag's volume by Wm. Bridge Cooke and Henry Q. Middendorf which will make it much more readily available to those who lack the time or inclination to delve into the intricacies of Lohwag's scientific German. Copies have been deposited in the library of the United States Department of Agriculture, which was the source of the original from which Mr. Cooke and Mr. Middendorf made their translation, in the Mycological Collections of the Bureau of Plant Industry at Beltsville, Maryland, and in the Lloyd Library, Cincinnati, Ohio. Without the assistance of Mr. Middendorf, Instructor in German at Brooklyn Polytechnic Institute, who was serving in the same U. S. Army Signal Corps camp with Mr. Cooke, the project could not have been completed.—JOHN A. STEVENSON.

THE POLYPORACEAE OF NEW YORK STATE

(THE GENUS PORIA)

This paper is a completion of the author's previous study of the New York State Flora of the fungi belonging to this family. The bulletin consists of 91 pages and includes keys and descriptions of 82 species of *Poria,* a glossary of terms, and an index. Under each species the more important taxonomic literature is cited, followed by an extensive description and taxonomic notes, and closing with pathological information, when known. There are 20 figures of line drawings. The bulletin may be obtained from the Extension Department of the New York State College of Forestry, Syracuse 10, N. Y., at the actual cost of printing, 60 cents per copy.—B. B. KANOUSE.

RED FLY-AGARIC IN FLORIDA

Amanita muscaria L. is usually red or reddish in Europe and yellow in America. On Dec. 22, 1945, a colony of red plants, ten in number, was found near Gainesville by Marjorie Gratz in low mixed woods with sweetgum, oak, pine, etc. There was no variation in the color of these hymenophores; all were pure-red (*ruber*), shining, with a few cream patches, mostly about the margin, which was striate in the older specimens. In size, shape and other characters the plants were a good match for Bresadola's colored plate 8 in his Iconographia Mycologica. The yellow form of the species is rare about Gainesville, in pine woods. So far as I know, the red form has not previously been reported from Florida.—W. A. MURRILL.

FOMES FRAXINEUS IN FLORIDA

This rare species was collected Aug. 11, 1946, in quantity on a diseased laurel oak trunk in Gainesville, where I had been watching it for three years. I had formerly found small, unsatisfactory specimens west of Gainesville on southern hackberry and near Orange Springs, in Marion Co., on willow. Overholts reported it from the state without mentioning the locality. The fresh hymenophores have a strong and very pleasing anise odor.—W. A. MURRILL.

SPECIMENS WANTED

Miss E. E. Morse is doing research on puffballs with embossed peridia. The bumps ("bosses") vary much in size and aspect. She finds that they have been collected in many localities since 1885, and that they were named *Lycoperdon lepidophorum* by Ellis. An approved present day name is *Calvatia lepidophora* (Ellis) Lloyd.

Miss Morse would be glad to receive specimens at the Life Sciences Bldg., Univ. of Calif., Berkeley 5, California.—A. H. S.

MYCOLOGIA

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THREE ZOÖPAGACEOUS FUNGI THAT CAPTURE AND CONSUME SOIL-INHABITING RHIZOPODS

CHARLES DRECHSLER[1]

(WITH 8 FIGURES)

Three fungi, all subsisting by capture of terricolous rhizopods, are described herein as new species of the Zoöpagaceae. Two of the new forms can be set forth in their asexual and sexual reproductive phases as well as their vegetative stage; though the details of morphology whereby they differ from forms previously made known appear of rather commonplace character. Their prey, like the prey of most predaceous members of the family, and, indeed, like the host animals of most parasitic members, consists of amoebae of the familiar pelliculate type developing abundantly in agar plate cultures planted with partly decayed vegetable materials. Although the third form can be presented only in its vegetative and asexual reproductive stages, the vegetative stage here offers marked departure in its predaceous relationship to a non-pelliculate, frequently reticulate rhizopod, while the asexual reproductive phase is given distinctiveness by the unusual design of the curiously topknotted conidia.

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[1] Pathologist, Division of Fruit and Vegetable Crops and Diseases, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration, United States Department of Agriculture, Plant Industry Station, Beltsville, Maryland.

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A RHABDOSPORA-LIKE SPECIES OF STYLOPAGE SUBSISTING ON AMOEBA VERRUCOSA

A maizemeal-agar plate culture which, after being permeated with mycelium of *Pythium ultimum* Trow, had been further planted with a small quantity of partly decomposed friable barley (*Hordeum vulgare* L.) straw collected near Greeley, Colorado, early in October, 1945, showed after 20 days dozens of large amoebae congregated in areas adjacent to the superadded material. On microscopical examination under low magnification the clustered animals gave much the same appearance as had been noted earlier in the groups of large amoebae captured by my *Zoöpage phanera* (3: 26–30) and more recently again in the assemblages of robust individuals of *Amoeba terricola* Greeff (*sensu strictiore*) taken captive by my *Acaulopage marantica* (8: 143-149). Under higher magnification the captured animals (FIG. 1, *A–F; G, a, b; H*), which commonly measured 50 to 100 μ across, were each found to be surrounded by a clearly visible, firm pellicle, in part delicately rippled and in part disposed more smoothly about broadly protruding pseudopodia. In the colorless, rather dispersedly granular sarcode could readily be distinguished a single somewhat prolate ellipsoidal nucleus measuring commonly 17 to 23 μ in length and 14 to 19 μ in width. As the nucleus showed always a slightly darker globose central body, mostly 7.5 to 10.5 μ in diameter, within the clear outer layer, the animal was immediately recognized as *Amoeba verrucosa* Ehrenb.—as the same widespread soil-inhabiting rhizopod that previously has been found attacked endoparasitically by *Cochlonema megalosomum* Drechsl. (8: 128–137), *C. symplocum* Drechsl. (9: 258–266), and *C. agamum* Drechsl. (12: 120–133). Although this rhizopod has further been reported as subject to destruction by the predaceous hyphomycete *Dactylella tylopaga* Drechsl. (4), it has not hitherto been found captured by any member of the Zoöpagaceae.

In the areas where capture of *Amoeba verrucosa* was just beginning to become noticeable from a grouped arrangement of relatively few individuals, the animals were often held through adhesion to only a single meagerly branching mycelial filament (FIG. 1, *A*), mostly 1.4 to 3 μ wide, whose phycomycetous character was

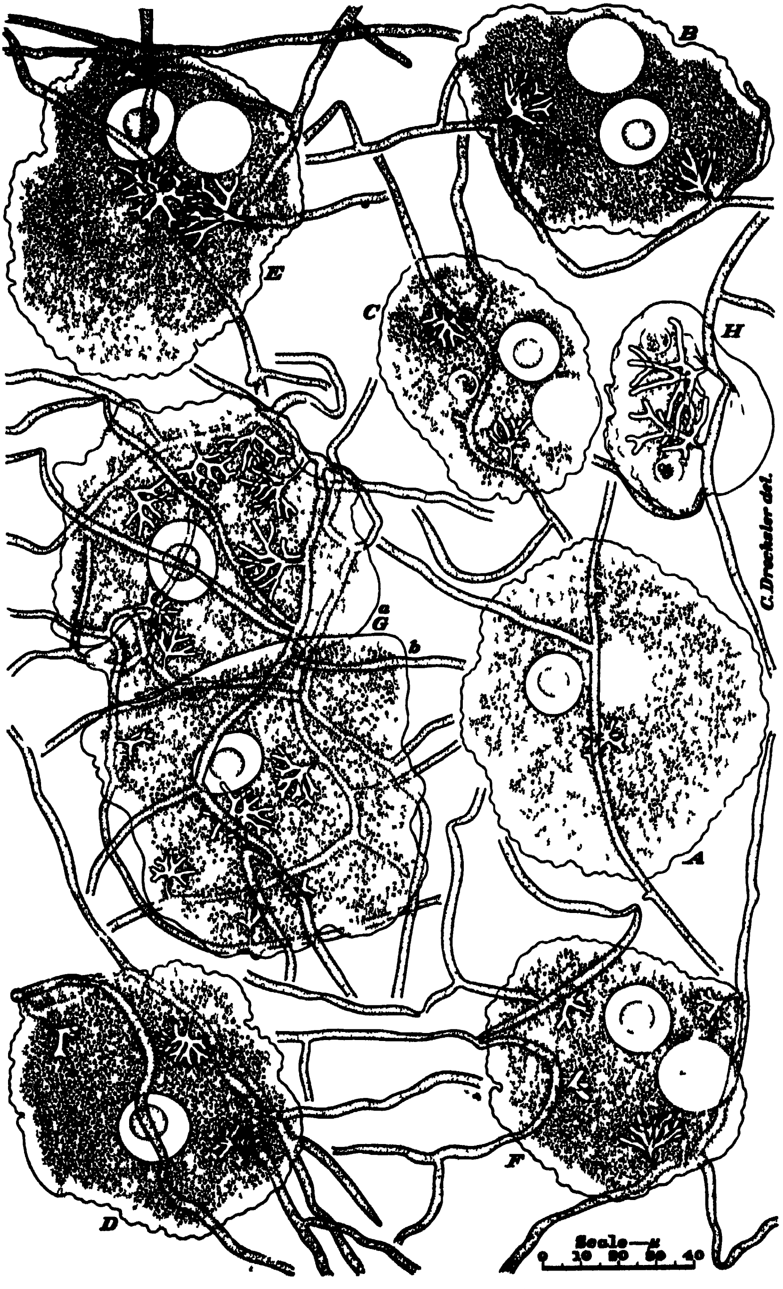

FIG. 1. *Stylopage rhabdoides.*

shown clearly in a lack of all intercalary cross-walls. After an animal had been taken, branches were evidently put forth more abundantly from the adhering portions of filament than from adjoining portions; so that the captive became increasingly invested with hyphal elements (FIG. 1, *B–D*). As the rhizopod usually continued long to wallow about by extending pseudopodia now in one direction now in another, it was not surprising that the investing hyphae were soon found to pursue markedly irregular courses. Yet even where the animal's struggles seemed less resolute the new hyphae that were put forth locally appeared likewise much given to capricious turns and to rather pronounced haphazard variations in width. Similar haphazard irregularity in the elongation of enveloping branches was observable also in instances where the rhizopod was captured by two (FIG. 1, *E*, *F*) or more (FIG. 1, *G*, *a*, *b*) separate hyphae, as often happened where the fungus had been present for some time and had thus been able beforehand to extend mycelial filaments more copiously. Consequently in areas where many captives had become unhappily congregated in readily noticeable groups, the animals, whether single or huddled in pairs (FIG. 1, *G*, *a*, *b*), were nearly always found intricately enveloped, above and below, in a confusion of promiscuously branching hyphae.

Usually at a rather early stage in the envelopment of the captured animal, a narrow process, or sometimes two narrow processes, would be extended through its pellicle from the adhering filament or filaments. On attaining a length of several microns each of the processes would widen abruptly at the tip and then would branch dichotomously at close intervals to form a pedicellate haustorium with short divaricate assimilative branches. Further envelopment of large animals usually brought intrusion of additional haustoria, so that in the end six or seven such organs were commonly found present (FIG. 1, *G*, *a*, *b*), and in more than a few instances as many as ten or twelve. The progressive expropriation of materials by these haustoria did not immediately have any noticeable effect on the sarcode, or on the nucleus, or on the operation of the contractile vacuole. It was not until the animal's protoplasmic contents had been largely depleted that the nucleus degenerated visibly and that the contractile vacuole ceased to operate.

Sometimes when the last remnants of degenerating protoplasm lay beyond reach of the haustoria many of the assimilative branches most favorably situated would elongate at a relatively late stage (FIG. 1, *H*) to bring about thorough expropriation. In any case, when all granular residues had vanished, the contents of the haustoria themselves were withdrawn backward into the parent mycelium, leaving only the collapsed empty pellicle as evidence of the completed predaceous action.

Near the groups of captured animals the Colorado fungus gave rise on prostrate hyphae to erect conidiophores (FIG. 2, *A–E: a*) which at a height of 25 to 50 μ tapered rather markedly before they widened again in elongating further to form the single terminal conidium (FIG. 2, *A–E: b*). Sometimes the conidiophore (FIG. 2, *E, a*) growing out distally into a young conidium (FIG. 2, *E, b*) extended a lateral branch (FIG. 2, *E, c*) which soon began to form distally a second young conidium (FIG. 2, *E, d*). Occasionally the erect hypha (FIG. 2, *F, a*) would fail to produce a conidium at its tip, but instead gave rise to a lateral branch (FIG. 2, *F, b*) that subsequently was found producing a young conidium (FIG. 2, *F, c*). When definitive size was attained, two cross-walls were laid down close together in the narrow isthmus to separate each functional conidiophorous hyphal element (FIG. 2, *H, a; I, a–c*) from the conidium (FIG. 2, *H, b; I, d–f*). No instance of a conidiophore growing from below its delimited distal end to form a second conidium on a newly prolonged tip came to light in the fungus preying on *Amoeba verrucosa*. Absence of such successive development, and lesser length of the conidiophore—this dimension here did not usually exceed 50 μ—would seem to represent features distinguishing the fungus from my *Stylopage rhabdospora* (**5**: 374–377; **12**: 138–140), in which production of plural conidia on a successively elongated conidiophore has often been observed, and in which the conidiophores, even without taking any increments into account, have frequently been found measuring between 50 and 100 μ in height. With respect to shape the conidia (FIG. 2, *J, a–z*) closely resemble those of *S. rhabdospora,* and though they have been found of appreciably larger size the dimensional difference is not sufficiently pronounced to merit much emphasis.

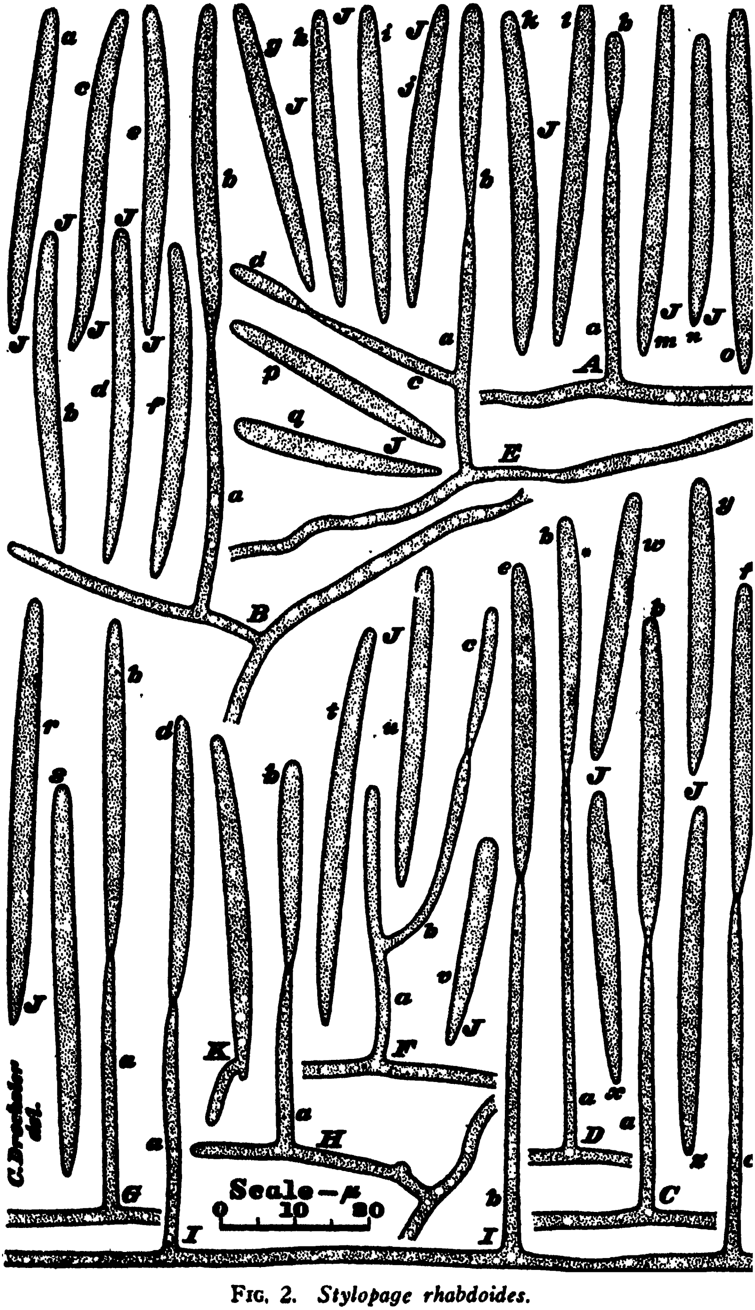

FIG. 2. *Stylopage rhabdoides.*

In nearly all areas occupied by it the fungus predaceous on *Amoeba verrucosa* showed moderately abundant sexual reproduction. Now and then instances were found where two neighboring mycelial filaments (FIG. 3, *A, a, b*) had evidently given rise to a pair of zygophoric branches (FIG. 3, *A, c, d*) which, after making contact with each other distally, became united at the tip (FIG. 3, *A, u*); a septum having meanwhile been laid down in each branch about 15 to 25 µ from the tip to delimit the conjugating parts as gametangia. Much more often, however, one of the two conjugating elements was supplied from a germinating conidium (FIG. 3, *B–J: a*) while the other was supplied from a mycelial hypha (FIG. 3, *B–J: b; D, c; H, c*). Most commonly the conidium germinated from one of its ends (FIG. 2, *K*). Sometimes the cross-wall delimiting the gametangium was laid down within the conidium itself, so that a small portion of the asexual spore was included in the conjugating cell (FIG. 3, *B, c; E, c; G, c*). In other instances the delimiting wall of the gametangium was laid down at the base of the germ-tube flush with the conidial wall (FIG. 3. *D, d, e; F, c; H, e*). Frequently, again, the septum was intercalated in the germ-tube, whether within a few microns from the base (FIG. 3, *C, c; E, d; H, d; J, c*) or, perhaps, 10 to 25 µ above it (FIG. 3, *I, c*). Although the opposing gametangium borne on a branch from a mycelial hypha sometimes included nearly the entire branch (FIG. 3, *E, f*), more often the delimiting septum here was found 5 to 25 µ above the branch origin (FIG. 3, *B, d; C, d; D, f; F, d; H, g; J, d*) and not infrequently it would set off the sexual cell from a stalk more than 25 µ (FIG. 3, *E, e; G, d; H, h*) or even more than 50 µ (FIG. 3, *D, g; I, d*) in length. Some conidia participated in the development of two zygospores by giving rise to two germ tubes that each produced a gametangium. In such instances the two germ-tubes came from opposite ends of the spore (FIG. 3, *D, d, e*), or, again, one of the two came from an end position (FIG. 3, *E, c; H, d*) while the other came from a more nearly median position (FIG. 3, *E, d; H, e*). Often the two gametangia borne on the germ-tubes conjugated with gametangia from separate mycelial hyphae (FIG. 3, *D, b, c; H, b, c*), but rather frequently, also, they conjugated with gametangia supplied from the same mycelial filament (FIG. 3, *E, b*).

In one observed instance a gametangium (FIG. 3, *E, c*) supplied by a conidium became united with two sexual branches (FIG. 3, *E, e, g*) supplied from the same mycelial filament. Occasionally a conidium that had already supplied two gametangia (FIG. 3, *H, d, e*) on separate germ-tubes was found putting forth a third germ-tube (FIG. 3, *H, f*).

Following fusion of the paired gametangia one of them—more usually the one contributed from the mycelial filament—soon began to swell out, commonly at a distance of about 5 μ from the union, to form a lateral intercalary globose excrescence (FIG. 3, *D, g; E, e; H, g, h; I, d; J, d*). When this excrescence attained a diameter of about 10 μ, and had received the entire protoplasmic content of both gametangia, it gave rise endogenously to the zygospore proper. At maturity the membrane of the globose part enveloped somewhat loosely the boldly verrucose, thick-walled, distinctly yellowish sexual spore (FIG. 3, *K–U*). Internally the ripe zygospore often seemed to have the unitary organization familiar among oöspores, its coarsely granular material apparently surrounding a single reserve globule and single refringent body (FIG. 3, *K, N, O, R, S, T, U*). At other times, however, two or three homogeneous reserve globules seemed present, usually without any clearly discernible refringent body (FIG. 3, *L, M, P, Q*).

The fungus manifestly is most closely related to *Stylopage rhabdospora*. In the vegetative stage it appears separated from that species by reason of its coarser mycelial hyphae and its utilization of a different *Amoeba* as prey. Though not wholly unknown in the Zoöpagaceae, utilization of more than one species of rhizopod is so exceptional among members of the family that it cannot be assumed for any member without unmistakable evidence. In view of the differences shown in its vegetative stage and in its conidiophores, there seems somewhat more reason for holding the fungus to be distinct from *S. rhabdospora* than for regarding it as being the same. It is therefore described as new under a specific epithet meaning "rod-like," which may perhaps serve helpfully in signalizing its conidial shape and in recalling the species most closely related to it.

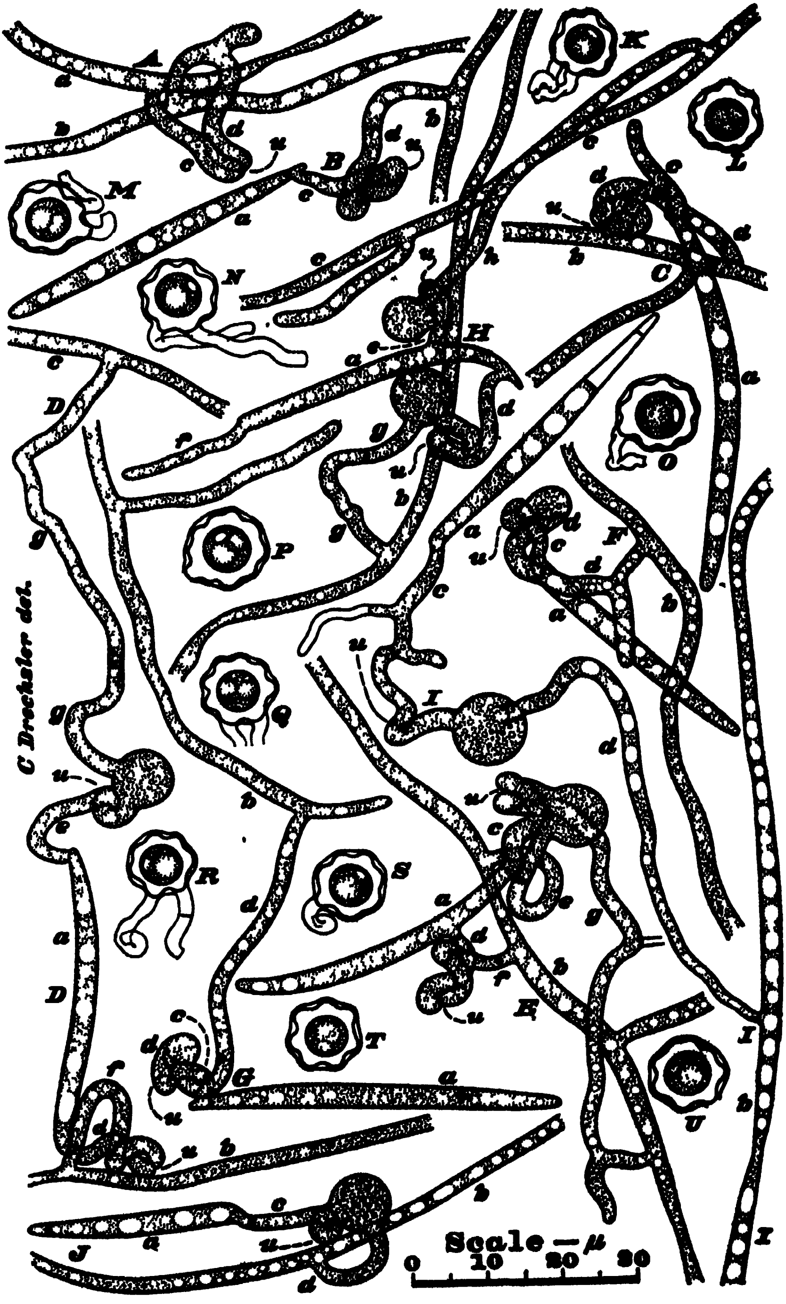

FIG 3 *Stylopage rhabdoides*

Stylopage rhabdoides sp. nov.

Mycelium effusum; hyphis continuis, incoloratis, filiformibus, parce ramosis, fere 1.4–3 μ crassis, ad animalia minuta extense inhaerentibus, saepe ea contorte implicantibus, pelliculam eorum perforantibus, haustoria intus evolventibus quae protoplasma exhauriunt; haustorio pedicellato, pedicello vulgo 3–7 μ longo, 0.5–1.5 μ crasso, apice abrupte latescente, saepius bis vel quater repetite bifurco, ita usque 16 ramulos divaricatos 5–18 μ longos et 1–2.5 μ crassos ferente. Hyphae fertiles incoloratae, erectae, simplices vel interdum parce ramosae, vulgo 20–50 μ altae, 1.4–2 μ crassae, sursum leniter attenuatae, apice unicum conidium gignentes; conidiis incoloratis, elongato-cylindraceis, saepe sursum leniter attenuatis et abrupte rotundatis, deorsum plus attenuatis, itaque basi acutiusculis, plerumque 25–57 μ longis, 2.7–3.5 μ crassis. Hyphae zygosporiferae saepius 15–85 μ longae, 1.5–3 μ crassae, vulgo 10–27 μ infra apicem septo divisae, ambae rarenter ex duabus hyphis mycelii exeuntes sed saepissime altera ex hypha mycelii altera ex conidio germinanti oriunda; duabus cellulis terminalibus (gametangiis) saepe plus minusve irregulariter flexuosis, interdum inter se circumplicantibus, apice inter se conjungentibus; zygosporangio circa 5 μ ab junctione oriundo, primum levi, sphaeroideo, vulgo 9–11 μ crasso, maturitate membrana ejus circa zygosporam laxe collapsa; zygospora aliquantum flavida, globosa, circa 8–10 μ crassa, in maturitate membrana valde verrucosa, cellulam viventem sphaeralem 5–6.5 μ crassam circumdante.

Amoebam verrucosam capiens consumensque habitat in stramento (foliis acere caulibusque) *Hordei vulgaris* putrescenti prope Greeley, Colorado.

Mycelium spreading; vegetative hyphae colorless, filamentous, sparingly branched, mostly 1.4–3 μ wide, adhering to and often extensively enwrapping minute animals, penetrating the pellicle of each captive and intruding haustoria to appropriate the protoplasmic contents; haustoria pedicellate, the pedicel usually 3–7 μ long, 0.5–1.5 μ wide, abruptly enlarging distally and bifurcating often 2 to 4 times in succession at wide angles, thus bearing commonly 4 to 16 assimilative branches 1–2.5 μ wide and in combined length of successive parts measuring 5–18 μ. Conidiophores simple or occasionally sparingly branched, colorless, 20–50 μ high, 1.4–2 μ wide, tapering gradually toward the apex whereon a single conidium is borne; conidia colorless, elongated-cylindrical, tapering slightly toward the abruptly rounded tip and rather pronouncedly toward the somewhat more pointed basal end, mostly 25–57 μ long and 2.7–3.5 μ wide. Zygophoric hyphae mostly 15–85 μ long and 1.5–3 μ wide, both occasionally rising from 2 mycelial filaments, but much more often one of a pair arising from a mycelial filament and the other from a germinating conidium, each in any case partitioning off a terminal cell 10–27 μ long; the paired terminal cells often more or less irregularly flexuous and sometimes intertwined, conjugating apically. Zygosporangium formed about 5 μ from the union and mostly in the gametangium supplied from the mycelium, at first smoothly subspherical and commonly 9–11 μ in diameter, its membrane at maturity collapsing loosely about the zygospore; the latter distinctly yellowish, subspherical, boldly verrucose, 8–10 μ in diameter, its thick wall surrounding a living cell 5–6.5 μ in diameter.

Capturing and consuming *Amoeba verrucosa* it occurs in decaying straw (stems, leaves, and chaff) of *Hordeum vulgare* near Greeley, Colorado.

A SLENDER-SPORED ACAULOPAGE PREYING ON TWO SPECIES OF AMOEBA

Several maizemeal-agar plate cultures which after being permeated with mycelium of *Pythium ultimum* had been further planted with small quantities of deciduous leaf mold collected near Mercer, Wisconsin, on November 14, 1945, showed in ten days a somewhat extensive development of an aseptate mycelium composed of hyphae about 1.5 μ wide that were active in capturing amoebae belonging manifestly to two separate species. The captured animals referable to one species (FIG. 4, *A*, *a*; *B*) often measured about 35 μ across when they were drawn into a rounded shape. The delicate and frequently rather minutely rippled pellicle here surrounded finely granular protoplasm together with a single globose or prolate ellipsoidal nucleus, commonly 8 to 9.5 μ long and 6 to 8 μ wide, in which about twelve slightly darker oblate ellipsoidal bodies could be distinguished in scattered positions close under the peripheral membrane. Unquestionably these captives were referable to the same species of *Amoeba* that previously had been found captured habitually by my *Zoöpage thamnospira* (**7**: 141–144) and my *Acaulopage tetraceros* (**10**: 289–291). The other animals serving as prey measured commonly 30 to 35 μ across when drawn into a rounded form (FIG. 4, *C*, *a*, *b*; *D*; *E*; *F*). They similarly were surrounded by a thin firm pellicle, and their protoplasm, too, was of finely granular, hyaline character; but the single globose or prolate ellipsoidal nucleus they contained, which often measured 4.3 to 8 μ in length and 4 to 7 μ in width, had its darker material collected in a globose central body, 2.2 to 3 μ in diameter, that frequently offered a homogeneous appearance (FIG. 4, *C*, *a*, *b*) but frequently, again, revealed a vacuole or lacuna of variable size (FIG. 4, *D, F*). While for purposes of identification this type of nuclear organization is less distinctive than might be desired, occurring evidently among many species of *Amoeba,* large and small, it nevertheless separates decisively any animal that embodies it from animals whose darker nuclear material (chromatin) is present in plural peripheral bodies.

Individuals of both species of *Amoeba* were held securely through adhesion to the aseptate hyphae. Usually the captive was invaded by only a single haustorium (FIG. 4, *A, a, b; B; C, b; E; F*), though occasionally two haustoria were intruded (FIG. 4, *C, a*). The assimilative organs were of the pedicellate type, consisting of a usually slender pedicel together with divaricate absorptive branches approximately equal in width to the mycelial hyphae. In some instances the pedicel seemed wider than is usual for this structure (FIG. 4, *C, b*) and in others appeared, besides, somewhat shortened (FIG. 4, *E*). The captured animals of both species remained alive, stubbornly operating their contractile vacuoles until most of their protoplasmic material was expropriated. When ultimately death came, the nucleus degenerated; its degenerating substance and all granular remnants of cytoplasm then being assimilated by the fungus. . Subsequently the contents of the haustorium were withdrawn backward into the parent hypha, leaving only the empty evanescent envelope of the absorptive apparatus within the equally evanescent pellicle of the rhizopod.

Thus amply nourished from abundant prey the fungus gave rise freely to asexual reproductive apparatus consisting of long, slender conidia (FIG. 5, *A, a–g; B–D*) borne erectly on short sterigmata projecting upward from procumbent hyphae (FIG. 5, *A–D; E, a–i; F, a–g*). In some instances a conidium was found delimited from its sterigma by a basal septum while protoplasm still filled the young spore throughout its length (FIG. 5, *B*). Conidia filled with protoplasm from base to tip were often found detached (FIG. 5, *G, a–c*) after being subjected to the disturbance unavoidable in covering material with a cover glass. In undisturbed cultures the conidia, after being delimited at the base, usually remained attached while a distal portion, including from one-tenth to one-fifth of the length of spore, was evacuated of contents; so that, as

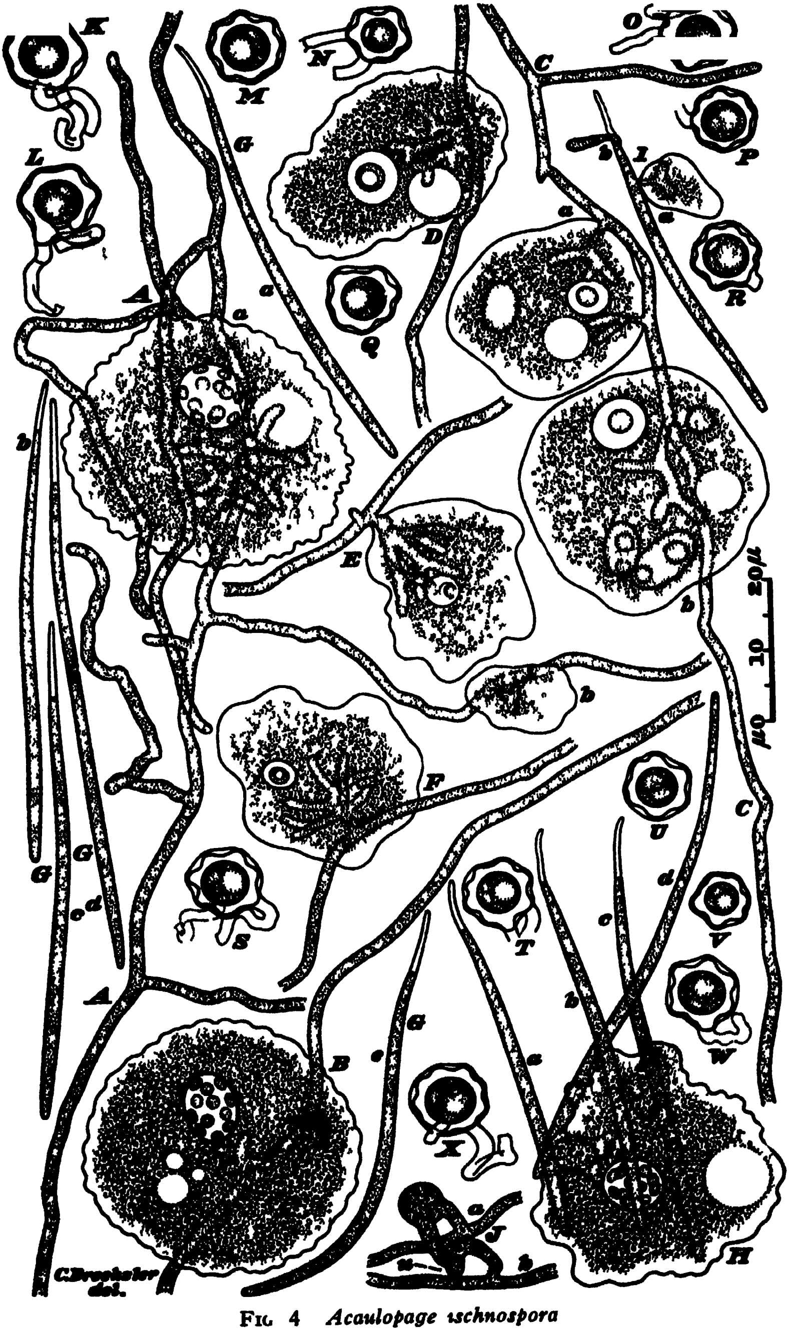

Fig. 4 *Acaulopage ischnospora*

a rule, spores that had become detached spontaneously bore an empty portion of tubular envelope as an apical appendage (FIG. 4, *G, a–e;* FIG. 5, *H, a–p*). Whether they bore an empty appendage (FIG. 4, *H, a–c*) or were filled with protoplasm throughout (FIG. 4, *H, d*), detached conidia were readily capable of infecting a susceptible amoeba by adhering to its pellicle and then invading its sarcode with a haustorium. Usually animals attacked in such commonplace parasitic manner, especially when they were of good size, continued in their locomotion for some time, carrying the spores along with them. However, when a conidium intruded a haustorium into a smaller adhering amoeba measuring perhaps only about 10 μ across (FIG. 4, *I, a*)—a nucleus could not usually be distinguished in these undersized specimens—the animal's locomotion was arrested no less decisively than when capture was effected by a mycelial filament (FIG. 4, *A, b*). As might be expected, capture and invasion of an amoeba by a conidium did not prevent the conidium from putting forth a vegetative germ-tube (FIG. 4, *I, b*).

Usually after asexual reproduction had been proceeding for some time the fungus also produced sexual apparatus in readily noticeable quantity. As in *Stylopage rhabdoides* and many other zoöpagaceous forms, zygospore development took place only sparingly before conidia were formed; for here, too, zygophoric branches from mycelial hyphae (FIG. 4, *J, a, b;* FIG. 5, *I, a, b*) only occasionally would pair and conjugate with others of similar origin. Once a tract of substratum became bestrewn with detached conidia, however, more spirited conjugation ensued between sexual branches arising from mycelium filaments (FIG. 5, *I–M: a*) on the one hand, and sexual branches arising as germ-tubes from conidia (FIG. 5, *I, c; J–M: b*) on the other. Owing to the slenderness and frequently rather irregular course of the conjugating hyphal elements the cross-walls delimiting the gametangia were often not clearly discernible; and the place of union between the gametangia often remained uncertain for similar reasons. Where both delimiting septa (FIG. 5, *M, c, d*) and the apical union (FIG. 5, *M, u*) were clearly revealed, the globose enlargement destined for the formation of the zygospore was more often found developing in the gametangium on the branch contributed by the my-

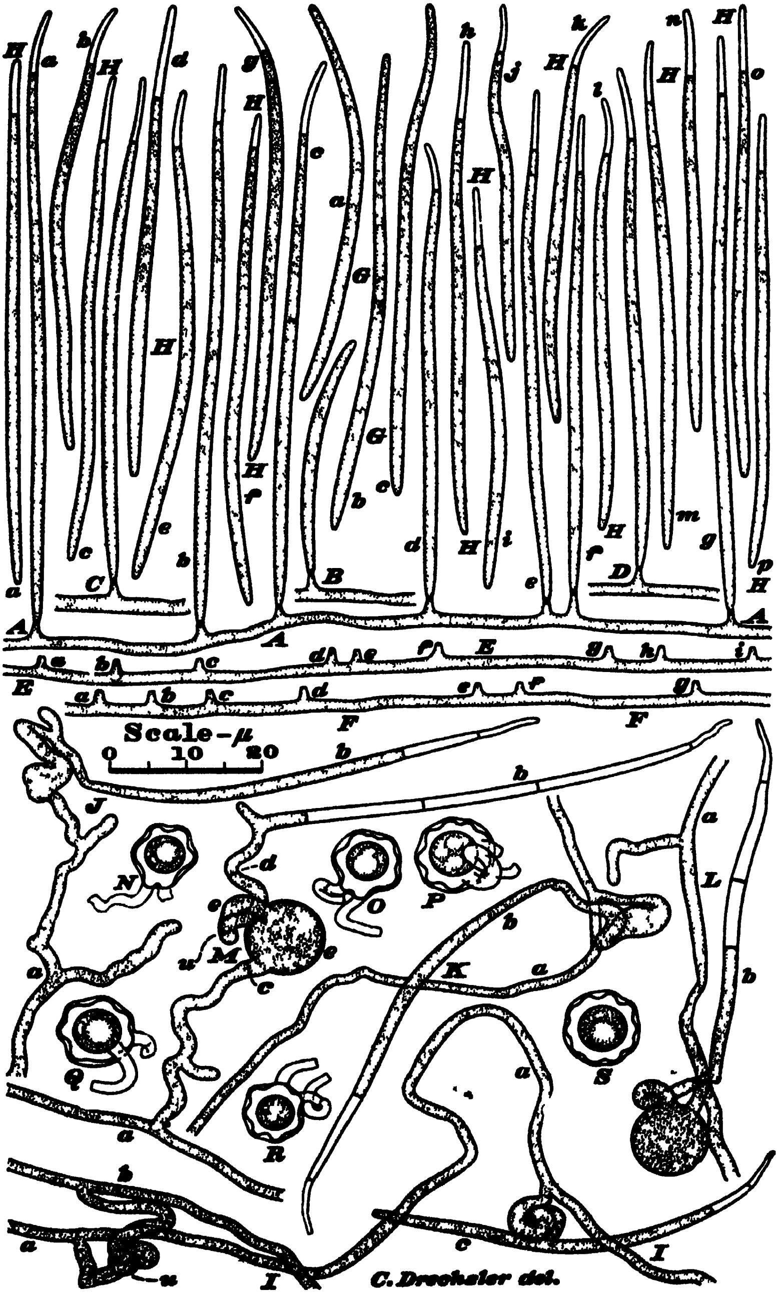

FIG 5 *Acaulopage ischnospora*

celial hypha (FIG. 5, *M, e*) than in the gametangium borne on the germ hypha. As in many related species the progressive evacuation of the conidium entailed in the growth of the zygosporangium was marked by deposition of two to four successive retaining walls within the conidial envelope (FIG. 5, *J–M: b*). When the sexual apparatus reached maturity (FIG. 4, *K–W;* FIG. 5, *N–S*) the membrane of the globose zygosporangium was found collapsed somewhat loosely about a pronouncedly verrucose, thick-walled, yellowish zygospore that showed an internal organization rather similar to the unitary organization familiar in the oöspores of many oömycetes—their granular protoplasm being disposed in a parietal layer surrounding a homogeneous central reserve globule.

In the genus *Acaulopage* to which it manifestly belongs, the fungus would seem to be distinguished from previously described species more especially by the unusual length and slenderness of its distally appendaged conidia. It is therefore presented as new under a specific epithet compounded in part of a word meaning both "thin" and "withered."

Acaulopage ischnospora sp. nov.

Mycelium effusum; hyphis continuis, incoloratis, filiformibus, parce ramosis, plerumque 1–2 μ crassis, ad animalia minuta inhaerentibus, pelliculam eorum perforantibus, haustorium (quandoque 2 haustoria) intus evolventibus quod protoplasma exhaurit; haustorio pedicellato, pedicello fere 2–6 μ longo, 0.5–1 μ crasso, apice abrupte latescente, semel vel quater repetite bifurco, ita 2–12 ramulos divaricatos 2–12 μ longos 1–2 μ crassos ferente. Conidia incolorata, ex sterigmatibus erectis, plerumque 1.5–4 μ altis, basi 1–1.5 μ crassis, sursum attenuatis, apice 0.5–0.7 μ crassis, inter se 3–25 μ distantibus oriunda, vulgo in partibus duabus constantia: pars supera vacua, 4–13 μ longa, basi 0.8–1.2 μ crassa, sursum leniter attenuata, saepius plus minusve marcida vel collapsa; pars infera protoplasmatis repleta, filiformis, utroque parvulum attenuata, plerumque 50–80 μ longa, 1.6–2 μ crassa. Hyphae zygosporiferae irregulariter flexuosae, quandoque inter se circumplicantes, ambae rarenter ex duabus hyphis mycelii exeuntes sed saepissime altera ex hypha mycelii altera ex conidio germinanti oriunda. Zygosporangia primo levia, sphaeroidea, plerumque 8–11 μ crassa, membrana eorum in maturitate circa zygosporam laxe collapsa; zygospora aliquantum flavida, globosa, 7–10 μ crassa, valde verrucosa, membrana ejus 1–2 μ crassa cellulam viventem sphaeralem 4.3–6.5 μ crassam stricte circumdante.

Amoebas duarum specierum 20–40 μ latas capiens consumensque habitat in foliis arborum (*Betulae, Aceris, Ulmi*) putrescentibus prope Mercer, Wisconsin.

Mycelium spreading; vegetative hyphae continuous, colorless, filamentous, sparingly branched, 1–2 µ (mostly about 1.5 µ) wide, adhering to minute animals, penetrating the pellicle of each animal thus captured, and intruding a haustorium (sometimes 2 haustoria) to appropriate the protoplasmic contents; haustoria pedicellate, the pedicel usually 2–6 µ long, 0.5–1 µ wide, abruptly enlarging and bifurcating successively 1 to 4 times and thus bearing 2 to 12 divergent assimilative branches 2–12 µ long and 1–2 µ wide. Sterigmata arising abruptly from procumbent hyphae at intervals frequently of 3–25 µ, commonly 1.5–4 µ high, 1–1.5 µ wide at the base, tapering upward to a width of 0.5–0.7 µ at the tip whereon is borne erectly a single conidium. Conidia colorless, usually composed of two parts: an upper empty membranous part generally 4–13 µ long, 0.8–1.2 µ wide proximally, gradually tapering upward, often more or less collapsed; and a lower filamentous living part tapering slightly toward both ends, commonly 50–80 µ long and 1.6–2 µ wide. Zygophoric hyphae often irregularly flexuous, sometimes winding about one another in some measure, both of them occasionally arising from separate mycelial filaments, but much more frequently only one arising from a mycelial filament, the other being supplied from a germinating conidium; zygosporangium at first smoothly subspherical and measuring 8–11 µ in diameter, but its membrane at maturity collapsing loosely about the zygospore; the latter yellowish, subspherical, 7–10 µ in diameter, boldly verrucose, having a wall 1–2 µ thick that closely surrounds a spherical living cell 4.3–6.5 µ in diameter.

Capturing and consuming two species of *Amoeba* commonly 20–40 µ in width, it occurs in decaying leaves of deciduous trees (*Betula, Acer, Ulmus*) near Mercer, Wisconsin.

AN ACAULOPAGE DESTRUCTIVE TO A RETICULATE RHIZOPOD

Several soft maizemeal-agar plate cultures which when well overgrown by *Pythium ultimum* had been further planted with small quantities of ash (*Fraxinus* sp.) leaves collected near Greeley, Colorado, early in October, 1945, showed after 35 days numerous ovoid bodies distributed sparsely over much of the agar surface, each curiously ornamented at its apex with a small tuft-like empty appendage. When the younger ovoid bodies, in which the appendage was still filled with protoplasm (FIG. 6, *A, a*), were examined closely they could often be seen attached basally to a hyphal branch that led backward to a scanty aseptate my-

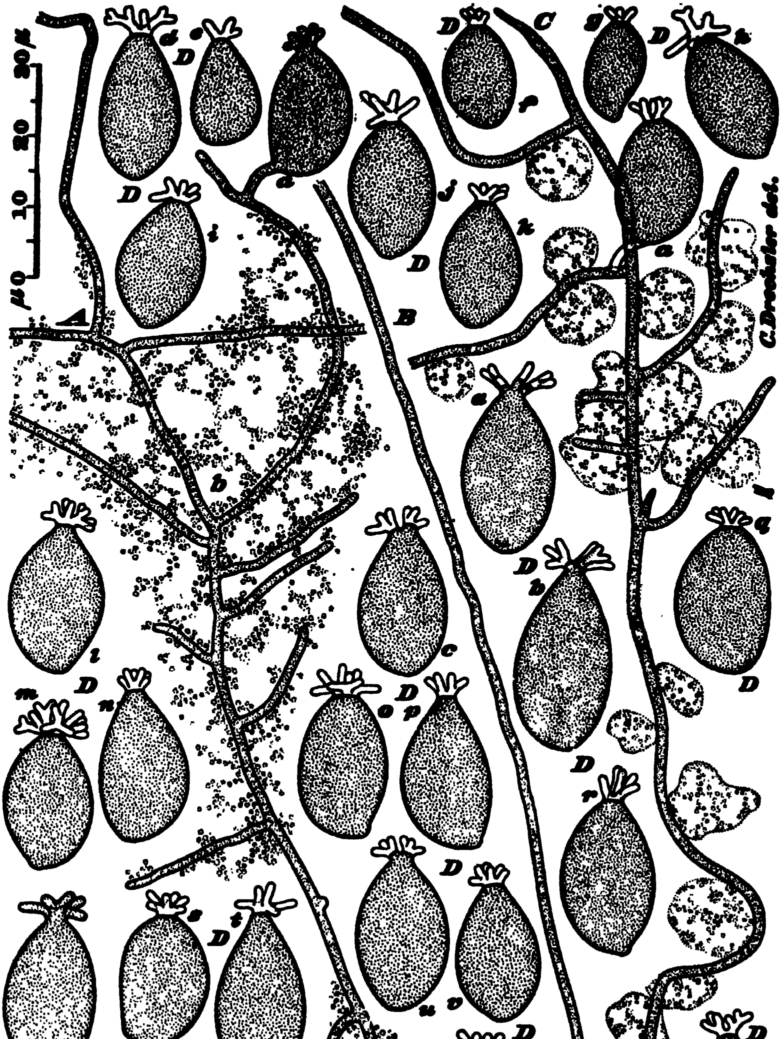

FIG. 6. *Acaulopage crobylospora.*

celium composed of filaments mostly about 1.3 μ wide. In following the longer hyphae through the soft agar substratum, branching was generally encountered at rather long intervals, but here and there, over stretches often 50 to 100 μ or more in length, branches were given off in closer arrangement. As a rule the regions of such more copious ramification had an untidy appearance, owing to the presence of promiscuously scattered deposits of loose granular material (FIG. 6, *A, b*). On continued exploration an instance came to light wherein a ramifying mycelial tract (FIG. 7, *A*) was surrounded not with the usual messy deposits, but with an extensive mass of living protoplasm that kept on changing its shape continually through protrusion and retraction of pseudopodia. Nearby, in addition, several smaller protoplasmic masses, all having finely granular consistency like the main mass, from which they had evidently become separated, were found in irregular alignment along the hyphae. The smaller masses, together with the large mass, were invaded with short, frequently somewhat curved branches (FIG. 7, *A, a–n*) presumably functional as haustoria despite their meager outward differentiation. A few minute spurs (FIG. 7, *A, o, p*) about 2.5 μ long and 0.6 μ wide, that were found projecting from one of the longer branches, offered a little the appearance of adhesive organs, though it was not evident that they helped in holding fast the protozoan. As other modifications seemed lacking, it could only be presumed that escape of the animal was prevented by adhesiveness of the mycelial filaments themselves.

The captured protozoan was not surrounded by any pellicle—at least not by any pellicle thick enough to be clearly visible under the microscope. Its irregular shape and lack of integument gave ground for the suspicion that the untidy deposits of granular material could well have come from the disintegration of similar animals—a suspicion soon amply confirmed through the discovery of protoplasmic masses showing transitional stages of granular disorganization (FIG. 6, *B, C;* FIG. 7, *B–E*). Owing to the nearly normal condition of the actively struggling captive it was without difficulty recognized as being conspecific with numerous protozoans still at liberty in the culture. For the most part these protozoans were submerged in the soft agar, where they appeared as

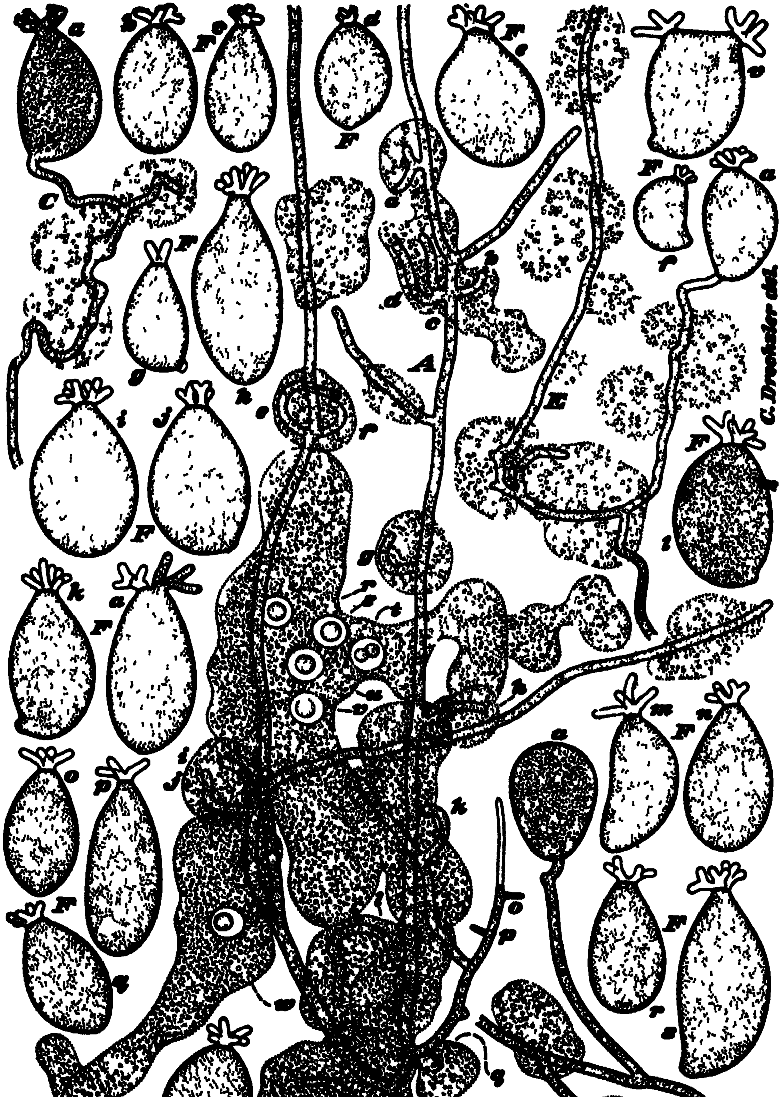

FIG. 7. *Acaulopage crobylospora.*

three-dimensional networks measuring 50 μ to 1 mm. across, and composed largely of anastomosing protoplasmic strands 2 to 6 μ wide. At the periphery of the networks new strands were protruded rather briskly, and these, on anastomosing with one another, would form additional meshes; though simultaneously other meshes nearby might disappear through retraction of protoplasmic branches. As the multiple pseudopodial activity was not usually well coördinated the locomotion of the whole animal appeared rather slow, but nevertheless was fast enough for the species to spread throughout the culture. On the surface of the agar substratum the protoplasm seemed more inclined to collect in a thin sheet from which irregular arms would extend out, freely anastomosing here and there, to enclose lacunae of variable shape and extent. At the base of the pseudopodia the animal showed very little of the strongly acuminate modification illustrated in Leidy's (**15**: pl. 47, FIGS. 5–12; pl. 48), Penard's (**16**: 549, FIGS. 1–4), Cash's (**2**: pl. 8, FIGS. 3, 4), and Kudo's (**14**: 293, FIG. 134, e) figures of the reticulate *Biomyxa vagans* Leidy—a modification that Calkins (**1**: 350) cited as a distinguishing character of the genus *Biomyxa* in his key of the subclass Proteomyxa under the class Rhizopoda. The animal seems to fit better the description of *Leptomyxa reticulata* Goodey (**13**), a proteomyxan rhizopod originally described from soft agar plate cultures that had been inoculated with soil. It would appear to conform to the characterization of the genus *Leptomyxa* with respect to multinuclear condition; for in captured specimens plural nuclei (FIG. 7, *A, r–w*), measuring commonly 4.4 to 5 μ in diameter and containing individually a slightly darker central body 2.3 to 2.8 μ wide, seemed recognizable. In newly captured specimens, further, as also in free animals, multiple contractile vacuoles were distributed at varying intervals. The colorless, highly transparent character, and finely granular, almost homogeneous consistency of its protoplasm readily distinguished the animal from *Penardia mutabilis* Cash (**2**: 90–91), as well as from other colored genera compiled in the Proteomyxa.

In initiating asexual reproduction, hyphal branches little differentiated from other mycelial elements gave rise terminally to swellings that at first were of subspherical shape. After some time, however, further enlargement took place mainly by elongation vertically into the air (FIG. 7, *B, a*), so that the swelling soon came to consist of an egg-shaped body with its long axis often nearly perpendicular to the supporting filament, its broadly rounded basal end resting in the agar, and its narrower end extended erectly into the air (FIG. 6, *A, a; B, a;* FIG. 7, *C, a; D, a*); the ovoid shape being conspicuously modified through apical prolongation of the body into a tuft of divergent processes having individually about the same width as the mycelial hyphae. Thereupon, as the protoplasm was withdrawn from the supporting hyphal branch and a basal retaining wall was laid down, the ovoid body became delimited as a conidium (FIG. 6, *C, a;* FIG. 7, *E, a*). Meanwhile the contents also of the distal processes were withdrawn backward, and a retaining wall was formed to delimit the living conidial cell from the empty membranous topknot. In some instances where the apical branches were relatively long—5 μ being approximately their greatest length (FIG. 6, *D, a;* FIG. 7, *F, a*)—a cross-wall might be laid down in them to mark an intermediate stage in their evacuation. Now and then some of the branches would become evacuated while others still retained their contents (FIG. 7, *F, a*); and occasionally, again, the protoplasmic mass would be left extending slightly into the proximal portion of the topknot, so that plural retaining walls were needed to delimit two or more tubular elements separately (FIG. 6, *D, b, c*). Where a single retaining wall delimited the living cell distally in the usual manner (FIG. 6, *D, d–y;* FIG. 7, *E, b–u*) considerable diversity in the appearance of the membranous topknot, nevertheless, came about from differences in the number, length, and divergence of its constituent branches. In a few instances conidia of unusual width at the distal end were found ornamented with two well-separated tufts (FIG. 7, *F, v*).

Although the fungus is here described primarily from cultures prepared with Colorado material, its conidia have come under observation repeatedly for more than a decade in cultures planted with leaf mold and other kinds of decomposing vegetable detritus originating from different localities in Maryland, Virginia, Delaware, New York, Maine, and Wisconsin. However, owing to usually rather early evanescence of the branches bearing them, their connection with a predaceous mycelium was not ascertained previously. A mistaken inference as to their probable identity was drawn from their fortuitous resemblance to frequently intermixed conidia produced by an apparently undescribed species of *Rhopalomyces* that often developed in the same soft agar plate cultures; the error being encouraged not merely by general similarity in size and shape, but also by the circumstance that the *Rhopalomyces* spores had their thin outer membrane extended emptily at either end. Yet the loosely protruding membrane of the *Rhopalomyces* spore was never seen disposed in a tuft; so that the predaceous fungus may conveniently be described under a specific epithet having reference to its curiously topknotted conidia.

Acaulopage crobylospora sp. nov.

Mycelium sparsum; hyphis filiformibus, incoloratis, primum continuis, plerumque parce ramosis, 1–1.8 μ (vulgo circa 1.3 μ) crassis, animalia minuta impedientibus, deinde ramulos assumentes fere 5–25 μ longos in eadem intrudentibus qui protoplasma magnam partem exhauriunt. Conidia in superficie materiae animalia ambientis sparsim oriunda, ex cellula viventi et crista vacua constantia: cellula viventi incolorata vel aliquantulum fumida, ovoidea, 10.5–27 μ longa, 6.8–14.3 μ crassa; crista vacua in 2–15 tubulis 1–5 μ longis 0.8–1.3 μ crassis consistens, saepius ad instar arbusculae divaricata.

Speciem *Leptomyxae* (forsitan *Leptomyxam reticulatam*) impediens necansque habitat in foliis *Fraxini* proper Greeley, Colorado, atque in humo silvarum et aliis materiis plantarum putrescentibus prope Beltsville, Maryland, et prope Georgetown, Delaware, et prope Webster, New York, et prope Presque Isle, Maine, et prope Butternut, Wisconsin, et in Arlington, Virginia.

Mycelium scanty; vegetative hyphae filamentous, colorless, at first continuous, for the most part only meagerly branched, measuring 1–1.8 μ (commonly about 1.3 μ) in width, holding minute animals and intruding into them assimilative branches usually 5–25 μ long which largely appropriate the protoplasmic contents. Conidia formed sparsely on the surface of the material surrounding the animals, colorless or slightly smoky, their single living cell usually of ovoid shape, mostly 10.5–27 μ long and 6.8–14.3 μ wide, bearing on its apex a frequently bush-like branching crest consisting of 2 to 15 empty membranous tubules 1–5 μ long and 0.8–1.3 μ wide.

Capturing and destroying *Leptomyxa* sp. (perhaps *Leptomyxa reticulata*) it occurs in decaying leaves of *Fraxinus* sp. near Greeley, Colorado, and also in deciduous leaf mold and other decaying plant materials near Beltsville, Maryland, near Georgetown, Delaware, near Webster, New York, near Presque Isle, Maine, near Butternut, Wisconsin, and in Arlington, Virginia.

DESTRUCTION OF A RETICULOCYTE RHIZOPOD BY A PREDACEOUS HYPHOMYCETE

In a culture abundantly infested with the reticulate rhizopod habitually taken as prey by *Acaulopage crobylospora,* this animal was found being captured and destroyed by a septate mycelium belonging presumably to a hyphomycete of the predaceous series most familiarly exemplified in *Arthrobotrys oligospora* Fres. On the longer filaments of this mycelium (FIG. 8, *A, B*) were borne here and there irregularly ramifying lateral branches. These branches were found surrounded by the same untidy granular deposits habitually associated with *A. crobylospora,* and they manifestly represented special assimilative elements despite their meager outward differentiation. Although the septate mycelium, with its constituent hyphae measuring about 3 μ in width, was appreciably coarser than the continuous mycelium of the zoöpagaceous form, it yet bore

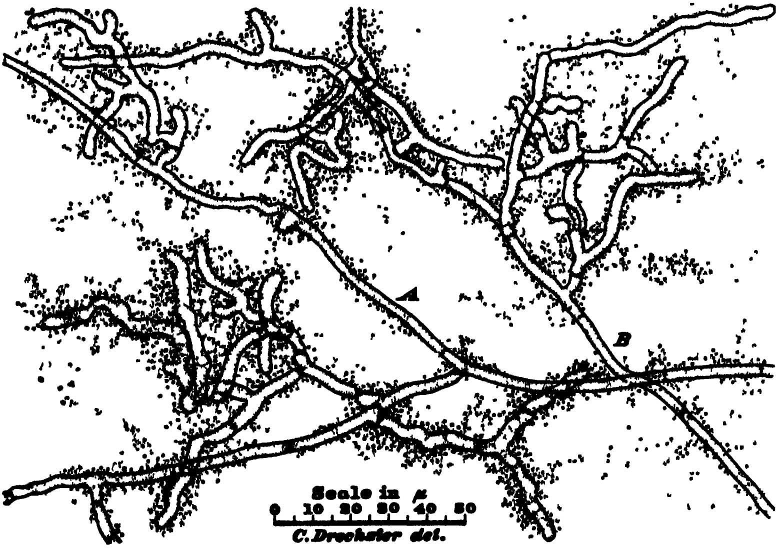

FIG. 8. Mycelium of a hyphomycete.

a striking resemblance to the latter—a resemblance obviously deriving from similarity in biological relationship to the same peculiar rhizopod. Unfortunately no reproductive bodies of any kind were produced whereby the specific identity of the septate mycelium might have been determined. A possibility worthy of consideration is that this mycelium might have belonged to one of the several described species, including notably *Dactylella atractoides* Drechsl. (**11**: 357–360), *Dactylella heptameres* Drechsl. (**11**: 352–354), *Dactylella rhombospora* Grove (**6**: 539–540), *Dactylella rhopalota* Drechsl. (**11**: 354–357), *Dactylella tenuis* Drechsl. (**6**: 538–539), and *Dactylaria pulchra* Linder (**11**: 349–352) which, though obviously referable taxonomically to the predaceous series of hyphomycetes, have not hitherto been observed in any important biological relationship to animals. At the time the species mentioned were tried out in cultures infested with nematodes and rhizopods of various kinds, the appearances usual in the destruction of nonpelliculate proteomyxan rhizopods were unknown to me, and therefore would very probably have been disregarded had they been present

BUREAU OF PLANT INDUSTRY, SOILS, AND AGRICULTURAL ENGINEERING,
U. S. PLANT INDUSTRY STATION,
BELTSVILLE, MARYLAND

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EXPLANATION OF FIGURES

FIG. 1. *Stylopage rhabdoides;* drawn to a uniform magnification with the aid of a camera lucida; × 500 throughout. *A,* Specimen of *Amoeba verrucosa* captured through adhesion to a meagerly branched mycelial filament from which a single haustorium has been intruded. *B, C,* Specimens of *A. verrucosa,* each captured through adhesion to a branched hypha from which two haustoria have been intruded. *D,* Specimen of *A. verrucosa* captured through adhesion to a branching hypha somewhat extensively enwrapping it; three haustoria have been intruded into the animal *E,* Specimen of *A. verrucosa* held captive through rather extensive adhesion of mycelial hyphae; from these hyphae three haustoria have been intruded into the animal. *F,* Specimen of *A. verrucosa* captured through somewhat extensive adhesion to two branched hyphae, from each of which two haustoria have been intruded. *G,* Two specimens of *A. verrucosa, a* and *b,* huddled together and extensively enwrapped by hyphal elements belonging to three branching systems; seven haustoria have been intruded into *a,* six into *b. H,* Small specimen of *A. verrucosa* which after being captured through adhesion to a mycelial hypha, and subsequently being almost completely expropriated of its protoplasmic content by two rangy haustoria intruded into it, has succumbed to death.

FIG. 2. *Stylopage rhabdoides;* asexual reproductive apparatus drawn to a uniform magnification with the aid of a camera lucida; × 1000 throughout. *A–D,* Portions of prostrate hyphae from each of which has arisen an erect conidiophore, *a,* continuous at its narrowed distal end with a young conidium, *b. E,* Prostrate hypha from which has arisen an erect conidiophore, *a,* which is still continuous with the young conidium, *b,* being formed distally on it; from *a* has been extended a lateral branch, *c,* which is continuous with the young conidium, *d. F,* Portion of prostrate mycelial filament from which has arisen an erect hypha, *a,* that has given off a branch, *b,* which is still continuous with the young conidium, *c,* being formed terminally on it. *G, H,* Portions of prostrate hyphae, each with an erect conidiophore, *a,* that has become delimited from the conidium, *b,* borne at its tip. *I,* Portion of prostrate hypha from which have arisen three conidiophores, *a–c,* each delimited distally from the single conidium, *d–f,* borne terminally on it. *J,* Random assortment

of detached conidia, *a–z*, showing usual variations in size and shape. *K*, Conidium germinating.

FIG. 3. *Stylopage rhabdoides;* sexual reproductive apparatus drawn to uniform magnification with the aid of a camera lucida; × 1000 throughout. *A*, Two mycelial hyphae, *a* and *b*, that have put forth the sexual branches *c* and *d*, respectively, which have paired and are conjugating apically; *u*, place of union. *B, C*, Two young units of sexual apparatus; in each a conidium, *a*, and a mycelial hypha, *b*, have produced the sexual branches *c* and *d*, respectively, which through deposition of septa have formed gametangia that are conjugating apically. *D*, Two units of sexual apparatus derived from a conidium, *a*, and two separate mycelial hyphae *b* and *c;* the two sexual branches, *d* and *e*, arising as germ-tubes have been cut off to form gametangia which have conjugated severally with the gametangia formed on the sexual branches *f* and *g*, originating from the hyphae *b* and *c*. *E*, Two sexual units derived from a conidium, *a*, and a mycelial filament, *b;* the germ hyphae *c* and *d* have formed gametangia that have conjugated with others formed on the two sexual branches, *e* and *f*, extended from the filament *b;* a third sexual branch, *g*, given off by the filament *b* has attached itself as a supernumerary element to the conjugating pair *c* and *e*. *F, G*, Two units of sexual apparatus, each deriving from a conidium, *a*, and a mycelial filament, *b;* a gametangium supplied mainly, if not wholly, by the germ-tube *c* having conjugated with a gametangium borne on a sexual branch, *d*, from the mycelial hypha. *H*, Two sexual reproductive units derived from a germinating conidium, *a*, and two mycelial hyphae, *b* and *c;* gametangia supplied by two germ hyphae, *d* and *e*, have conjugated with gametangia borne on the sexual branches *g* and *h*, coming from *b* and *c*, respectively; the conidium has further put forth a third germ-tube, *f*. *I, J*, Two sexual reproductive units, each deriving from a conidium, *a*, and a mycelial hypha, *b;* in each unit a gametangium borne on a germ-hypha, *c*, has conjugated with one supplied by a sexual branch, *d*, coming from mycelial hypha *b*. *K–U*, Random assortment of mature zygospores showing usual variations in size, shape, and internal organization, as well as in disposition of membranous zygosporangial envelope. (*u*, Place of union between paired gametangia.)

FIG. 4. *Acaulopage ischnospora;* drawn at a uniform magnification with the aid of a camera lucida; × 1000 throughout. *A*, Portion of mycelium with two captured amoebae, *a* and *b*, into each of which a haustorium has been intruded; the captive *a* has a nucleus with about twelve flattened peripheral bodies. *B*, Portion of hypha with a captured amoeba having a nucleus of same structure as in *A, a;* a haustorium bearing four assimilative branches has been intruded. *C*, Portion of hypha with two captured amoebae, *a* and *b*, each containing a nucleus with a darkish central body; captive *a* shows an ingested fungus spore on the left side; captive *b* shows two similar ingested spores on the lower side and a smaller spore on the upper right side. *D–F*, Portions of hyphae, each holding captive a specimen of the same *Amoeba* sp. as that shown in *C, a* and *b;* a well developed haustorium is present in each animal. *G*, Detached conidia, *a–e*. *H*, Four conidia, *a–d*, attached to an *Amoeba* of the same species as *A, a;* the ypsiliform haustorium intruded by each conidium illustrates an early stage of development. *I*, Conidium that has captured a small amoeba, *a*, and has intruded a haustorium into it; a

germ-tube, *b*, is being extended from a distal position adjacent to the apical appendage. *J*, Two mycelial hyphae, *a* and *b*, that have supplied sexual branches with conjugating gametangia; a globose zygosporangium is being formed in the gametangium from *a*; *u*, place of union. *K–X*, Mature zygospores showing usual variations in size, shape, and internal organization, as well as in disposition of the surrounding membranous envelope.

FIG. 5. *Acaulopage ischnospora*; drawn at a uniform magnification with the aid of a camera lucida; × 1000 throughout. *A*, Portion of prostrate hypha with seven sterigmata, each bearing a (*a–g*) conidium that terminates in an empty appendage. *B*, Portion of prostrate hypha with a sterigma from which has been delimited a small, somewhat immature conidium still filled with protoplasm throughout. *C*, *D*, Portions of prostrate hyphae, each supporting erectly a mature, distally appendaged conidium. *E*, *F*, Portions of prostrate mycelial hyphae whereon are borne denuded sterigmata in numbers of nine (*a–i*) and seven (*a–g*), respectively. *G*, Somewhat immature detached conidia, *a–c*, filled with protoplasm throughout. *H*, Mature detached conidia, *a–p*, showing usual variations in size and shape, and in length of empty appendages. *I*, Mycelial hypha, *a*, that has produced two sexual branches, one of which has paired with a sexual branch from another mycelial hypha, *b*, while the other has paired with a sexual germ hypha from a detached conidium, *c*; *u*, place of union. *J–L*, Sexual reproductive units wherein a sexual branch from a mycelial hypha, *a*, has conjugated with a germ hypha coming from a detached conidium, *b*. *M*, Sexual reproductive unit likewise resulting from conjugation of a gametangium contributed by a mycelial hypha, *a*, with a gametangium supplied by a germinating conidium, *b*; *c*, *d*, cross-walls proximally delimiting the two gametangia; *e*, gametangium of mycelial origin in which the zygosporangium is developing; *u*, place of union. *N–S*, Mature zygospores showing usual variations in size, shape, and internal organization, as well as in disposition of the surrounding membrane.

FIG. 6. *Acaulopage crobylospora*; drawn at a uniform magnification with the aid of a camera lucida; × 1000 throughout. *A*, Portion of branching mycelium surrounded with untidy deposits of granular protoplasmic detritus, *b*; connected to it is a full-grown conidium, *a*, whose apical processes are still filled with protoplasm. *B*, Portion of mycelium bordered with masses of degenerating protoplasm; connected with it is a full-grown but slightly immature conidium, *a*. *C*, Portion of mycelium bordered with masses of degenerating protoplasm; connected to it is a mature conidium, *a*, with empty apical appendage. *D*, Random assortment of detached conidia, *a–y*, showing usual variations in size and shape of the ovoid living cell as well as in make-up of the apical appendage.

FIG. 7. *Acaulopage crobylospora*; drawn at a uniform magnification with the aid of a camera lucida; × 1000 throughout. *A*, Portion of branching mycelium with a captured specimen of *Leptomyxa* sp. (possibly *L. reticulata*); *a–n*, assimilative branches; *o–q*, narrow spurs perhaps having an adhesive function; *r–w*, nuclei of rhizopod. *B*, Portion of mycelium bordered with masses of degenerating protoplasm; connected to it is a young growing conidium, *a*. *C*, *D*, Small portions of mycelium, each bordered with several masses of degenerating protoplasm; connected to each portion is a full-grown conidium, *a*, with its apical outgrowths still filled with protoplasm.

E, Portion of mycelium bordered with masses of degenerating protoplasm; connected to it is a mature conidium, *a*, with empty appendage. *F*, Random assortment of detached conidia, *a–v*, showing variations in size and shape of the living ovoid cell, as well as in make-up of the apical appendage; in *a* three of the six branches in the appendage are still filled with protoplasm; in *v* two appendages are present on opposite sides of the flattened apical end.

FIG. 8. Mycelium of a hyphomycete distributed in an untidy expanse of granular detritus left after disintegration of a captured specimen of *Leptomyxa* sp. (possibly *L. reticulata*); two main mycelial filaments, *A* and *B*, are present, together with several irregularly ramifying assimilative branches attached to them.

MORE NOTES ON GASTEROMYCETES[1]

S. M. Zeller

(with 11 figures)

This publication includes primarily some new species of *Calvatia* and *Scleroderma* and a review of certain American species of *Disciseda* and *Holocotylon.* Notes on a few other new or noteworthy species of Gasteromycetes comprise the remainder of the paper.

Arcangeliella lactarioides sp. nov.

Fructificationes 2.5–3 cm. crassae 1.5–2 cm. altae, agaricoideae, sphaeroideae demum expansae vel convexo-pileatae, disco leniter depressae, stipitatae; superficie glabra, innato-fibrillosa, sicca, pallide lutescenti, siccitate brunneola; peridio tenui, filamentoso, ductibus lactiferis praedito; columella percurrenti, lactiginosa, postremo stipitiformi, 4–6 mm. crassa; gleba alba, demum cremea, siccitate brunneola, inferne aperta, adnexa, ventricosa; locellis labyrinthiformibus, sporis albis partim impletis; septis albidis, ductibus lactiferis farctis; basidiis clavatis, quadrisporis, longis sterigmatibus munitis; sporis ellipsoideis, verrucosis (ut in Russulis Lactariisque), pedicellatis, 8–10.5 × 6–6.3 μ.

Fructifications 2.5–3 cm. broad, 1.5–2 cm. high, resembling a stout agaric button, subspherical becoming expanded, convex pileate, somewhat depressed at summit, stipitate; surface smooth, innately fibrillose, dry, pale yellowish, drying brownish; peridium thin, especially below or at margins, where it breaks away from base of stem (columella), filamentous with lactiferous ducts; columella percurrent, becoming a stipe as the cap expands, 4–6 cm. broad, lactiferous; gleba white, becoming creamy, drying brownish, exposed below, adnexed, very ventricose, cavities labyrinthiform, partially filled with white spores; septa whitish in section, filled with lactiferous ducts; basidia clavate, four-spored, with long sterigmata bearing the spores acrogenously; spores ellipsoid, verrucose with protuberances of various sizes and somewhat connected by reticulate lines (as in *Russula* and *Lactarius*), pedicellate, 8–10.5 × 6–6.3 μ.

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In fir woods below timberline (elev. 7500 ft.) in Diller Canyon, Mt. Shasta, California, July 27, 1940, *Wm. B. Cooke*, 14666, **type** (in Zeller Herb.).

This species is a clear connecting link between the Gasteromycetes and *Lactarius*. It has spores like *Russula* and *Lactarius*, but the spores are borne acrogenously. Pine squirrels are fond of the fruiting bodies. The type was dried and no record of the color of the milk was made.

CALVARULA EXCAVATA Zeller (FIG. 2)

It was with some reluctance that the genus *Calvarula* was originally described [2] because the type collection is somewhat inadequate. Two additional collections at the Farlow Herbarium were taken in 1942 at Matheson Hammock, Dade county, Florida. Both of these contain numerous specimens in various stages of glebal development. The dried specimens, shrunken materially because of the gelatinous tramal peridium, are characterized by ridges over the surface indicating the location of the cortical plates. The surface becomes subgelatinous, drying avellaneous. The gleba is olivaceous, soft, with very thin fragile septa, which later break down into an olive-brown powdery mass, mostly spores. There is also a very slender, white columella which arises from the point of attachment and reaches somewhat beyond the center of the fructification. These two large 1942 collections verify our earlier opinion that *Calvarula* is a genus distinct from *Protophallus*.

The description of *C. excavata* may be emended to include "columella unbranched, white, very slight and thread-like, extending about to center of fructification"; and "basidia forming a palisaded hymenium with paraphyses and cystidia; cystidia long, conic, acute."

CREMEOGASTER LEVISPORUS Mattirolo

A critical study of the type of this genus and species (a portion of which is in Zeller Herb. comm. by C. G. Lloyd, July, 1924) has led the writer to agree with Fischer [3] that it is a good genus independent from *Leucogaster* with which it was previously placed in synonymy.[4] It differs from *Leucogaster* in ellipsoidal, smooth spores which do not possess a gelatinous sheath.

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[2] Mycologia 31: 23–26. 1939.

[3] Fischer, Ed. Neue Beiträge zur Kenntnis der Verwandtschaftsverhältnisse der Gastromyceten. Ber. d. Schweiz. Bot. Ges. 45: 231–247. 1936 (see p. 232).

The peridium has a black rind covering a hyaline layer of prosenchyma with isolated patches (islands) of large-celled parenchyma; the whole up to 260 μ thick. The spores are 6.2–8.75 × 10–12.5 μ. Otherwise the structure is as Mattirolo [5] described it. The type specimen is very mature, not young as we previously stated.[4] This genus, along with *Leucogaster*, is one of the borderline genera between the *Melonogastraceae* and *Hymenogastraceae*. To include the two genera in *Melanogastraceae* as Mattirolo [5] has done is perhaps a little more satisfactory than to place them in *Hymenogastraceae*.

Gelopellis hahashimensis (S Ito & S. Imai) Zeller n. comb.

Syn. *Hysterangium hahashimense* S. Ito & S. Imai, Sapporo Nat. Hist. Soc. Trans. **15**: 10–11. 1937.

Ito & Imai pointed out the close similarity of this species to *G. Thaxteri* from which it differs chiefly in the size of spores, color of gleba, and columella. The columella of *G. hahashimensis* as described and as illustrated is oddly pendent, piercing the gleba from the top of the fructification at a point opposite from the base and point of attachment. Such a structure must have evolved from a percurrent columella which in this later stage of development has entirely lost its attachment with the base of the fructification. Should this be considered an aberrant form or should one expect to find the highest form of gleba within the Hysterangiaceae-Gelopellaceae-Protophallaceae group to be that without conspicuous columella, perhaps in forms like *Calvarula?* The writer has previously assumed that the modification of the columella and amplification of sterile tissues in the fructification points to higher development, as exemplified by the origin of the Phallaceae and Clathraceae within the Phallales, from families within the Hysterangiales (see Mycologia **31**: 17–30. 1939).

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[4] Zeller, S. M., and C. W. Dodge. Leucogaster and Leucophlebs in North America. Mo. Bot. Gard. Ann. **11**: 398. 1924.

[5] Mattirolo, O. Descrizione di una nuova specie italiana del genere *Cremeogaster* Mattirolo (*C. Klikae* nov. sp.) e considerazioni critiche sulla posizione sistematica di questo genere. Atti della R. Accademia della Scienze di Torino **69**: 237–248. 1934.

HOLOCOTYLON Lloyd (emended)

Fructifications subglobose; sterile base none; peridium easily separable, fragile, dehiscing irregularly; gleba of small, empty chambers separated by very thin, delicate, fragile but persistent, tramal partitions; hymenium composed of a compact palisade or loosely grouped paraphyses, conidiophores, and basidia; capillitium none; spores spherical to ellipsoid, colored, mostly pedicellate, smooth.

This southern genus resembles *Arachnion* somewhat in outward appearance, but not in structure of the gleba, as Lloyd has pointed out.[6] Most of the species have conidia borne on branched conidiophores and the basidiospores are borne on sterigmata of various lengths. The basidiospores and the conidia of the individual species are quite similar in appearance; in fact, in some species, like *H. anomalum*, it is difficult to distinguish between them. Conidiospores have not been discovered in many Gasteromycetes. The writer has seen them in one other genus, the Leucophlebs stage of *Leucogaster*. In that genus, however, the conidial stage is not in the same fructification with the basidial stage, at least not together at the same time, as in *Holocotylon*. It is also of interest that in *Holocotylon* and *Leucogaster* the sterigmata are long and of various lengths on the same basidium.

The taxonomic position of *Holocotylon* is obscure. The dehiscence is like *Calvatia*, but since it is without capillitium and maintains structural characters of the gleba to maturity, it does not conform to the *Lycoperdaceae*. Although it is undoubtedly epigeous, the writer is inclined to place *Holocotylon* in the *Hymenogastraceae* because it retains glebal characters to maturity; there are usually some thicker tramal septa dividing the gleba, and *Holocotylon* is perhaps less stable than the genera of *Lycoperdaceae*. The morphological development and cytology of such little-known genera as *Holocotylon* must be studied before their taxonomic relationships can be better established.

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[6] Lloyd, C. G. The genus *Holocotylon*. Myc. Writ. **2**: 254–255. f. 94–96. Pl. 73, f. 5–8. April, 1906.

HOLOCOTYLON BRANDEGEEANUM Lloyd (emended)

Fructifications depressed globose, up to 3 cm. broad; surface yellow, becoming bay brown, smooth, with adherent sand; peridium thin, fragile; gleba drying drab-gray (R) to drab (R), divided by an occasional major tramal septum; cavities empty; the usual tramal septa delicate, thin, fragile, white within, surfaces covered with chocolate to walnut brown (R) masses of spores; spores spherical, smooth, with one large oil globule, pedicellate, 5–6 μ.

In sandy soil.

SPECIMENS EXAMINED: MEXICO: Sinaloa, Culiacan, *T. S. Brandegee*, **type** (in C. G. Lloyd Myc. Coll., No. *22748*).

HOLOCOTYLON MEXICANUM Lloyd[7] (emended)

Fructifications subglobose to oblong, up to 15 mm. × 10 mm. × 8 mm.; surface white, smooth to somewhat cottony; peridium very thin, easily separable, leaving much of the gleba exposed at maturity; gleba buckthorn brown (R) to darker; cavities empty; tramal septa delicate, fragile, white within, surfaces covered with masses of light brown basidiospores; a few heavier whitish plates (similar in appearance to the peridium) dispersed through the gleba; hymenium loosely organized, composed of basidia and conidiophores; basidia in clustered groups over the surfaces of the tramal septa, four-spored, cylindrical, 8–10 × 1.5–3 μ; sterigmata slender, of various lengths, up to 18 μ long; basidiospores brown (almost hyaline under lens), smooth, ellipsoid, 3–5 × 2.5–3.5 μ, sometimes pedicellate; conidia obovoid, 2.5–4 × 2–3 μ.

In pastures or open places.

SPECIMENS EXAMINED: MEXICO, Tacuapan, *T. S. Brandegee*, **type** (in C. G. Lloyd Myc. Coll., No. *22626*); Michoacan, Morelia, *M. M. Solorzano* (in C. G. Lloyd Myc. Coll., No. *22746*, under the herb. name, *Holocotylon rigidum*).

The specimens in the type collection are quite broken and fragmentary. A microscopic examination reveals appearances as of a puffball infected with some hyphomycetous fungus because the spores are borne on sterigmata of various lengths, and also because of the presence of branched conidiophores. The conidia are not pedicellate. The writer found three basidia floating free in a microscopic mount from the type. The basidia were four-spored, with spores attached. The spores are borne on long sterigmata of various lengths, as in *Leucogaster*. In no other respect, however, is the fungus like *Leucogaster*. Some of the basidiospores to which the pedicels remain attached are similar to the spores of *Bovista* The collection from M. M. Solorzano, Morelia, Mexico, is undoubtedly the one to which Lloyd referred on p. 271 and illustrated in fig. 113 (Myc. Writ. **2**: 271. *f. 113*. July 1906). It is however the same as *H. mexicanum*, rather than *H. texense*, and the specimens are in fine condition.

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[7] Lloyd, C. G. Myc. Writ. 2 (Letter No. 17): 1–2. Nov. 1, 1907.

HOLOCOTYLON TEXENSE Lloyd (emended)

Fructifications subglobose, somewhat depressed, 1.0–1.5 cm. broad, radicate by a rather stout rhizomorph; surface white, smooth, papery, somewhat areolated by the separation of the very thin, closely adnate, white exoperidium; peridium duplex, exoperidium as above, endoperidium papery thin, brown; gleba purplish brown at maturity; cavities empty; tramal septa papery thin, fragile, purplish brown at maturity, with two or three heavier tramal plates dividing the gleba from the base; basidia cylindrical forming a loose hymenium, four-spored; sterigmata slender, mostly near 12–18 µ long; basidiospores purplish brown, spherical, smooth (very slightly asperate as seen under oil immersion), long-pedicellate, 4–5 µ; conidia subhyaline, subspherical to broadly ovoid, smooth, 3–4.5 µ.

SPECIMENS EXAMINED: TEXAS, Walker County, Huntsville, *J. W. Stiles*, **type** (in C. G. Lloyd Myc. Coll., No. *22747*).

The type collection has become quite shattered (by insects?) and very little of the gleba is intact in most specimens. Basidia were found, however, with spores attached, and basidial characters indicate *H. mexicanum* and *H. texense* to be very closely related but yet quite distinct. The long-pedicellate basidiospores of *H. texense* are like those of a *Bovista*.

Holocotylon anomalum sp. nov.

Fructificationes circa 10 mm. altae, 7 mm. crassae, subglobosae vel turbinatae, rhizomorphis affixae; superficie alba, glabra, ochracea siccata; peridio tenuissimo, paene cartilagineo siccato; gleba olivacea; locellis parvis, irregularibus, vacuis; septis tramalibus brunneis, tenuibus, in angulis subscissilibus;

conidiophoro dichotomo-ramoso; conidiis ellipsoideis, subhyalinis, 2.5–3 × 3–4 μ; basidiis angusto-teretibus, hyalinis, longis sterigmatibus munitis; basidiosporis subglobosis vel crasso-ellipsoideis, brunneis, levibus, longe pedicellatis, 3.7–5 × 3–3.7 μ.

Fructifications about 10 mm. high, 7 mm. broad, subglobose to turbinate, with a distinct rhizomorphic attachment; surface white, drying tan, smooth; peridium very thin, drying almost cartilaginous; gleba olivaceous; cavities small, irregular, empty; tramal septa brown, thin, somewhat scissile where branched, lined on both sides by a distinct, crowded hymenium of large paraphyses and small basidia and conidiophores, basidia narrowly cylindrical, hyaline, with four long sterigmata; conidiophores mostly twice dichotomously branched; conidia ellipsoid, subhyaline, 2.5–3 × 3–4 μ, basidiospores subglobose to short ellipsoidal, brown, smooth, mostly long pedicellate, 3.7–5 × 3–3.7 μ.

On barren soil, Cisco, Eastland County, Texas, *E. A. Smith*, July 1938, **type** (in Zeller herb.).

Mr. E. A. Smith collected this species of *Holocotylon* along with a large collection (No. 1234) of *Disciseda Brandegeei*. The basidia are very narrow in this species and the conidiophores, which are twice bifid, appear very much like basidia with two long sterigmata which are once branched. Each conidiophore therefore bears four spores as do the basidia. Cytological studies to aid in determining the origin of basidiospores and conidiospores in *H. anomalum* might accordingly prove of value.

HYSTERANGIUM STOLONIFERUM var. **brevisporum** var. nov.

A typo differt: sporae 10–14 μ longae; fructificationes ± 2.5 cm. crassae.

As in the species, but larger, up to 2.5 cm. in diam., light tan becoming light brownish when dry, from a long (1–5 inches) radicate stolon; peridium 380–420 μ thick, composed of one layer of polygonal-celled parenchyma; gleba bluish when young, becoming brownish (drying buffy brown to light brownish olive), somewhat fragile; spores ellipsoid, light yellow, 10–14 × 5 μ.

Under moss beneath vine maple, Trout Creek Forest Recreational Area, Linn County, Oregon, *S. M. Zeller*, May 21, 1938, **type.**

Whereas the spores of the typical variety are 17–23 μ long, these are but 10–14 μ. Otherwise it agrees with the typical variety in all respects but size.

Leucogaster columellatus sp. nov.

Fructificationes 1–2 cm. diam. siccatae, subglobosae vel reniformes; superficie levi, subviscida, pallide brunnea; peridio tenui, hyphis parallelibus, hyalinis, gelatinosis composito, intus duro luteoloque siccitate; columella hyphis magnis, parallelibus, hyalinis, gelatinosis composita, fragili rubroluteaque siccitate; gleba alba, siccitate pallide lutea cretaceaque; locellis parvis, subrepletis; basidiis subteretibus vel anguste clavatis, 2–4-sporigeris, sterigmatibus usque ad 25 μ longis, 1–1.5 μ diam.; sporis sphaeroideis, hyalinis, 5–7.5 μ crassis, episporio lacunoso.

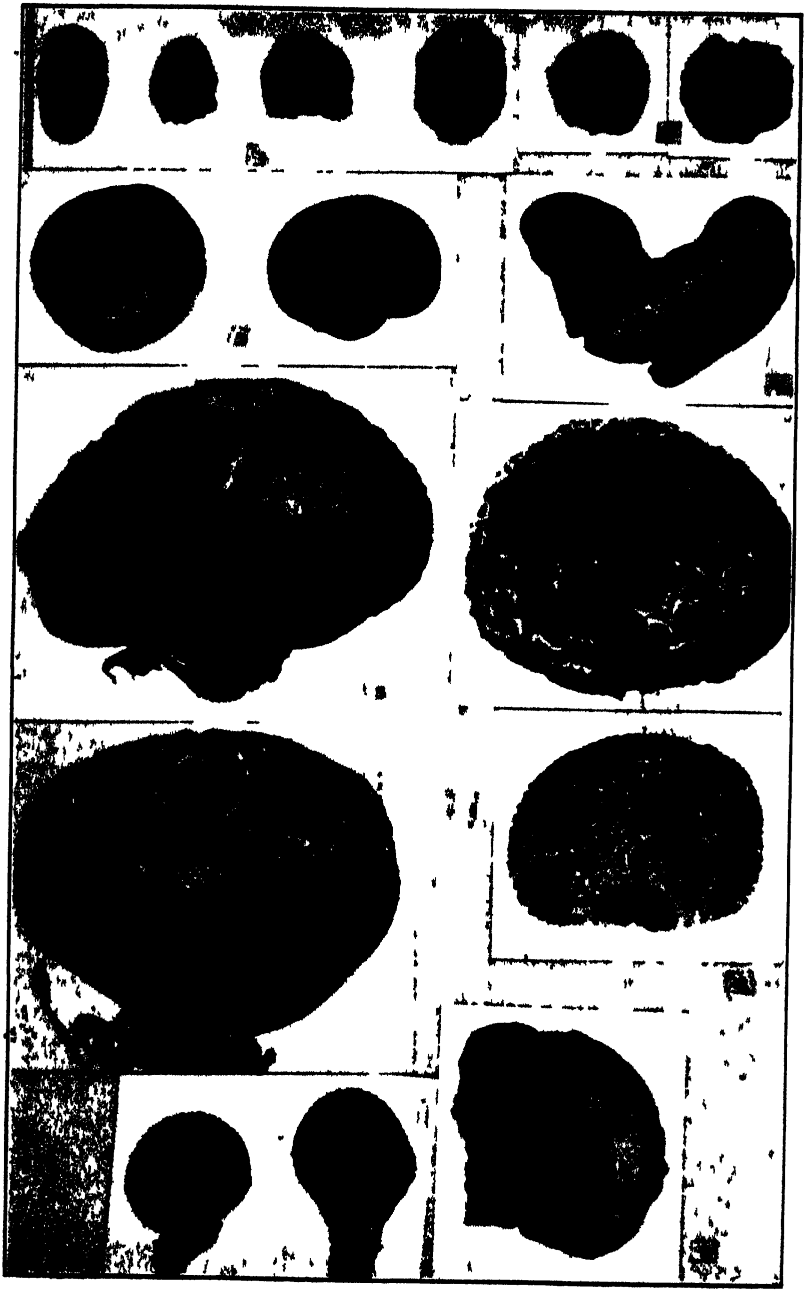
Fructifications 1–2 cm. in diameter (dry), subglobose to reniform; surface smooth, somewhat viscid with particles of humus adhering, light brown; peridium thin, of parallel, hyaline, gelatinized hyphae, drying flinty hard and quite amber in section; columella of large parallel, hyaline hyphae, gelatinized, drying brittle and reddish amber; gleba pure white, drying "light buff" (R), chalky texture; cavities small, almost filled with spores; basidia subcylindrical to narrow clavate, 2–4-spored; sterigmata of various lengths, up to 25 μ long, 1–1.5 μ in diameter; spores spherical, hyaline, surface pitted, 5–7.5 μ in diameter.

Hypogeous under *Pinus ponderosa,* "Rim of the World," northeast of San Bernardino, California, May 1923, *N. L. Gardner,* No. 581, **type** (in Herb. Univ. of California, No. *233, 330,* and small portion in Zeller Herb.).

This species is of special interest because of its columella. There are two fructifications in the type collection and in both the columella is very evident, reaching to the center of the fructification or farther. Because of the columella it may be that a new genus should be erected but all other characters are so typical of *Leucogaster* that it is placed in this genus, and the generic description may be amended to include species with a columella. This is perhaps as much justified as to include in *Lycoperdon* and other genera species with or without a sterile base.

Leucogaster longisterigmatus sp. nov.

Fructificationes subsphaeroideae vel oblongatae, 0.5–1 cm. diametro, usque ad 3 cm. long; superficie coactili hebetique, submarmorata, sordide brunneola vel atrobrunnea; fibrillis paucis, concoloribus; peridio 130–200 μ crasso, hyphis periclinalibus compactis, prosenchymaticis constituto; gleba alba vel sordide griseola; locellis magnis, sporis repletis; basidiis quadrisporigeris, pyriformibus, sterigmatibus longioribus quam basidiis, usque ad 25–35 μ longis;



FIGS. 1–7. Interesting Gasteromycetes.

sporis sphaeroideis vel subellipsoideis, crasse verrucosis, hyalinis, episporio utriculo gelatinoso hyalinoque, vestitis, 7.5–10 μ (11.2–13.8 μ episporio incluso).

Fructifications subspherical to oblong, 0.5–1 cm. diameter, up to 3 cm. long; surface felty and unpolished, somewhat marbled in places where impressions of lacunae show through, dingy, brownish to blackish brown; fibrils not prominent, concolorous; peridium 130–200 μ thick, of compact periclinal hyphae, approaching prosenchyma; gleba white to muddy grayish, lacunae large, filled with spores; basidia four-spored, with pedicels of various lengths, pyriform, 12–19 × 6–7 μ; sterigmata longer than the basidia, 25–37.5 μ long, stout; spores spherical or somewhat ellipsoid, coarsely verrucose, hyaline, enclosed in a hyaline, gelatinous sheath, 7.5–10 μ (11.2–13.8 μ including sheath).

Under coniferous duff, Monument Peak, Linn County, Oregon, June 8, 1940, *Dr. Helen M. Gilkey* and *Dr.* and *Mrs. D. P. Rogers,* **type.**

The type collection fortunately includes specimens from 2 mm. diam. up. Even these smallest specimens have mature lacunae at the center, but just under the peridium, however, all of the lacunae are not wholly differentiated and indicate a morphological origin differing from that reported for *Leucogaster floccosus* Hesse by Fischer.[8] In *L. longisterigmatus* the long sterigmata are very distinctive, for in all other species so far described the spores are sessile or nearly so.

Macowanites alpinus sp. nov. (FIG. 4)

Fructificationes usque ad 6 cm. crassae, agaricoideae; pileo in centro plano vel depresso, margine involuto; superficie levi, sicca, cremea vel ochracea; stipite brevi vel paene nullo, basi attenuato, paene albo vel cremeo, solido; gleba alba demum cremea, ventricosa, locellis magnis in centrum a peridiis vergentibus; peridio siccitate usque ad 4 mm. crasso, parenchymate spongioso composito, siccitate duro fragilique; basidiis quadrisporigeris, clavatis; sporis ellipsoideis, verrucosis, 7.5-8.8 × 6–6.5 μ.

Fructifications up to 6 cm. broad, agaricoid; pileus flat to depressed in center, margins incurved; surface smooth, dry, cream to buff shades when dry; stipe short-tapered below, almost wanting in some specimens; smooth, almost white, creamy, solid; gleba white, becoming cream color, ventricose, composed of anastomosing lamellae, forming large, labyrinthiform cavities; peridium (cap) very thick, up to 4 mm., dry, of spongy parenchyma, hard and brittle when dry; basidia four-spored, clavate; spores ellipsoid, verrucose, 7.5–8.8 × 6–6.5 μ.

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[8] Fischer, Ed. Mykologische Beiträge 25. Jugendstadien des Fruchtkörpers von Leucogaster. Mitt. Naturf. Ges. Bern. **1921**: 20–26. *illus.* 1922.

Under duff in fir woods, below Shasta Alpine Lodge in Cascade Gulch, up 7500 feet on Mt. Shasta, California, *Wm. B. Cooke,* No. 16797, **type**, Sept. 7, 1942.

Secotium aurantium sp. nov.

Fructificationes solitariae, stipitatae, 3.5 cm. altae; pileo circa 1.4 cm. crasso, 1.5 cm. alto, apice rotundato umbonato, superne claro-aurantiaco, inferne capucino-luteo; peridio tenui, interne albo, inferne a stipite inseparabili; stipite tereti, usque ad 3 mm. crasso, glabro, externe albo, interne albo farctoque, inferne funiculis albis radicanti, superne in columellam tenuem percurrentem procurrenti; gleba pallide brunnea, locellis parvis; hymenio paraphysibus crasso-clavatis basidiisque composito; basidiis crasso-clavatis, quadrisporigeris; sporis levibus, ellipsoideis, infra cicatricula sterigmatica ornatis, pallide brunneis, 11–13 × 6–7.5 μ.

Fructification solitary, stipitate, whole plant 3.5 cm. tall, head almost 1.4 cm. broad, 1.5 cm. high, rounded umbonate above, bright orange above, capucine yellow at base; peridium not breaking from stem, thin, white within; stem terete, up to 3 mm. in diam., smooth, white without, white and stuffed within, from a white cord-like rhizomorph below, extended above into a narrow percurrent columella; gleba light brown, cavities small; hymenium of paraphyses and basidia; paraphyses broadly clavate; basidia broadly clavate, four-spored; spores smooth, ellipsoid, with a terminal sterigmal scar, light brown, 11–13 × 6–7.5 μ.

On the ground, Mina Carlota, Sierra de San Juan, Trinidad Mountains, Cuba, *W. L. White,* No. 803, July 6, 1941, **type.**

The above collection consists of but one fructification which has a phalloid appearance because of the white cord-like rhizomorphs and general habit. The basidia and spores, however, are not like those of the phallaceous genera. Even though the spores and the general shape allow it to be included in *Secotium,* this species is placed there with considerable reservation, particularly until further collections may indicate more completely its morphological development.

SECOTIUM MACROSPORUM Lloyd, Myc. Writ. 1: 139. *pl. 13, f. 12–16* (March) 1930.

EMENDED DESCRIPTION: Fructifications subglobose to obovoid, seldom pileate, sometimes turbinate, 2–3 cm. tall, 1–2 cm. broad, surface smooth to somewhat scurfy, white to grayish, then brownish at maturity; peridium papery, tough, thin; columella slightly projecting below, percurrent, tapering upward, up to 3 mm. in diameter below (dried), solid, white within; gleba mostly of partitions radiating outward and upward from the columella, wood brown, becoming almost sepia; cavities small; basidia pyriform, four-spored, 12–15 × 6–7.5 μ; spores brown, spherical, stout-pedicellate, one large oil globule, 11–14 μ in diameter, epispore thick, at first smooth, then reticulated by anastomosing shallow fissures.

TYPE LOCALITY: In open grass lands, May to June. Dallas, Texas.

This species appears in general habit, shape, size, color, and surface markings like *S. arizonicum* Shear & Griffiths but the spores are distinct in markings and are of a darker color, resulting in a much darker gleba. The spores have very stout pedicels. A collection from Dr. Roderick Sprague, Mandan, North Dakota, seems identical in characters with that from Texas (type locality).

Pompholyx occidentale sp. nov.

Fructificationes depresso-globosae, 3–7 cm. crassae, 2–5 cm. altae, superne albae demum sordidae vel purpureo-brunneolae, inferne levigatae vel rugosiusculae; peridio 4–6 mm. crasso, coriaceo, strato interno tenuissimo membranaceoque, comparate facile ab externo strato separabili siccato; gleba primo viridifusca vel vinaceo-brunnea, firma, demum obscure vinaceo-brunnea, pallide brunnea siccata, postremo pulvere sporarum capillitiique brunnea repleta; septis albidis, postremo nonnumquam scissilibus; sporis sphaeroideis, obscure brunneis, echinulatis (echinis brevibus, truncatis), 5–7.5 μ crassis, basi breve pedicellatis vel hilis hyalinis munitis; capillitio obscure brunneo, 5–7.5 μ crasso. Odor foetidus.

Fructifications depressed globose, 3–7 cm. broad, 2–5 cm. high, white becoming sordid to purple brownish above, smooth, somewhat plicated into rounded ridges radiating from the point of attachment; peridium very thick, hard, leathery, 4–6 mm. thick, lined by a thin membrane which tends to adhere more to the gleba than to the peridium; gleba at first of a greenish or vinaceous brown color, firm, lacunae separated by whitish partitions, sometimes splitting along partitions at maturity, becoming dark vinaceous brown (R), drying lighter brown, a powdery mass of spores and capillitium; spores spherical, dark brown, echinulate with very short blunt spines, 5–7.5 μ in diameter, with a hyaline hilum or more often short pedicellate; capillitium dark brown with heavy walls, 5–7.5 μ in diameter. Odor when fresh similar to flowers of Eastern skunk cabbage, *Symplocarpos foetidus.*

Hypogeous becoming erumpent, under *Abies,* 5500–8000 ft. elevation on Mt. Shasta, August to September.

SPECIMENS EXAMINED: CALIFORNIA: Mt. Shasta, in west 40-acre lot at Horse Camp, *Wm. B. Cooke,* No. 14639, August 7, 1940; along Horse-Camp-Wagon-Camp Trail, *Wm. B. Cooke,* No. 15741, Aug. 18, 1941; and in Mud Creek Canyon above Mud Creek Dam, *Wm. B. Cooke,* No. 16671, July 2, 1942, **type** (in Zeller Herb.).

This species is placed in *Pompholyx* on the strength of Jaczewski's description[9] and rediscovery of *P. sapidum* Corda in Russia. In *P. occidentale* there is no evidence of nurse cells around the spores and the presence of a pedicel or a distinct hilum on the mature spore indicates this fungus should be included in *Pompholyx.* Young fructifications were not seen but should be studied that more may be known of their morphological development and the origin of the basidia and the early glebal structure.

Specimens of *Pompholyx sapidum* Corda that Jaczewski studied, are now to be found in the Patouillard Herbarium at Farlow Herbarium, Harvard University. In this collection there are two or three stages of maturity. The largest piece is quite young. In it the spores are hyaline, smooth, 7.5–11 μ in diam., with a large hilum and sometimes even a portion of the sterigma still attached. In the darker fragment of glebal tissue the spores are dark brown, deeply reticulated with large meshes, 12.5 μ in diam. The older spores show no sign of a hilum or place of attachment. These spores, when stained, show no nurse cells, but the ragged appearance of some of them are quite like *Scleroderma* spores. The older piece of gleba could be *Scleroderma.*

Corda's illustrations of the spores of *Pompholyx sapidus* are difficult to explain without studying again the specimens he saw.[10] His figure 4 shows dark brown, verrucose spores with a peculiar reticulation dividing the spore into three equal parts. Fig. 5 shows the hilum surrounded by a larger white area, as though a part of the epispore were torn away with the sterigma. If the epispore is torn away in this manner it seems incredible that the hilum would still show as a scar on the endospore, as Corda has it illustrated.

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[9] Jaczewski, A. Bull. Soc. Myc. de France, 9: 169–173. 1893.

[10] Corda. *Pompholyx sapidus.* Sturm Deutschl. Fl. 19 & 20: 47–50. *Tab. 15.* 1841.

The specimens which Jaczewski studied do not have spores like those illustrated by Corda, but they are similar to those of *P. occidentale.*

The two known species of *Pompholyx* are aromatic and may or may not be hypogeous. The peridium is harder or more leathery than in most species of *Scleroderma,* with which the genus has close affinities. In the mature spores of *Scleroderma* the hilum or any remains of the sterigma are wanting. Nurse hyphae or cells (Hülle) have not been found associated with the spores of *Pompholyx.* There is some doubt, however, that the spores of all species of *Scleroderma* are provided with nurse cells during the stages of maturation. Cunningham [11] has discussed this phenomenon to some extent, but there is some need for considerable study on the development of basidia and spores of echinulate-spored as well as reticulate- and verrucose-spored species of *Scleroderma.* What is the origin of the epispore markings? Do they all arise from the epispore or do some markings like reticulations originate from the nurse cells?

Cunningham [11] has mentioned *Pompholyx* as a synonym of *Scleroderma* (p. 277) but under his formal treatise on the genus he has omitted any reference to *Pompholyx.*

Scleroderma arenicola sp. nov.

Fructificationes subglobosae vel urceolatae, 2.5–6 cm. crassae; superficie glabra vel innato-fibrillosa, alba demum straminea vel luteola, siccitate pallide lutea vel sordide ochracea; peridio 1–3 mm. crasso, firmo, siccitate duro fragiloque, apice stellatim vel irregulariter dehiscenti; gleba brunneola vel sepia demum atroinquinanti, siccitate fusca, postremo pulverulenta, sporis sphaeroideis, fuscidulis, echinulatis reticulatisque, 15–22.5 μ diam.

Fructifications subglobose to urnshaped when stellately open at the top, 2.5–6 cm. in diameter; surface smooth or innate fibrillose, white becoming straw-color or yellowish, drying light buff to sordid ochraceous-buff, or with yellowish tints; peridium 1–3 mm. thick, firm, drying hard, brittle, dehiscing stellately at apex or rupturing irregularly; gleba brownish to sepia or blackish, drying fuscous, becoming powdery with remains of nurse-hyphae prominent; spores spherical, dark fuscous, echinulate with long sharp echinulae which tend to be ragged, not straight and stiff, large-meshed reticulations also visible through the dense echinulation, 15–22.5 μ in diameter.

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[11] Cunningham, G. H. The Gasteromycetes of Australasia XII. The genus *Scleroderma.* Linn. Soc. N. So. Wales, Proc. 56: 277–287. 1931.

In sand under *Pinus contorta* along the ocean coast, Waldport, Lincoln County, Oregon, August 4, 1928, *S. M. Zeller*, **type.**

This species is separated from the Friesian *Scleroderma Bovista* as described by Hollos chiefly in the larger size and the longer, sharper echinulae of the spores. This large-spored form among those with reticulate spores is essentially a northern and western species. This is undoubtedly the same species as that described by Coker and Couch as "*S. Bovista Fries.* Sense of Bresadola" and the size of spores of their Canadian citation (Canada. London. Dearness, No. *135B*) compares well with the Oregon material.

Scleroderma furfurellum sp. nov.

Fructificationes hypogeae, subglobosae, 3 cm. altae, 2 cm. crassae, rugosissimae, siccitate durae; superficie alba demum argillacea vel brunneola, superne squamis furfuraceis vestita; peridio duro, siccitate luteolo; gleba atra, e floccis albo-marmorata; sporis obscure fuscis, sphaeroideis, 10–12.5 μ diam., episporio crasso, leniter asperato.

Fructifications hypogeous, subglobose, 3 cm. tall by 2 cm. wide, much wrinkled, drying hard; surface white becoming clay-colored or brownish, covered especially above with bran-like scales, scurfy; peridium hard, yellowish when dry; gleba black, marbled with white veins, some remains of nurse hyphae among the spores; spores very dark, spherical, thick epispore, slightly roughened, 10–12.5 μ.

In sandy soil, Perkinston, Stone County, Mississippi, *T. W. Brasfield*, No. 544, Oct. 20, 1939, **type** (in Zeller Herb., communicated W. H. Long, *No. 8465*).

This species is characterized chiefly by the scurfy surface.

Scleroderma subviscidum sp. nov.

Fructificationes epigeae, subglobosae, 3–5 cm. crassae; superficie glabra, subviscida, alba vel griseola, siccitate luteola; peridio 1–2 mm. crasso, lento duroque, prosenchymatico hyphis hyalinis, gelatinosis, compacte implicatis composito; gleba osseo-brunnea, siccitate concolori, compacta, pulverea, pos-

tremo e sporis et hyphis hyalinis vel coloratis, 4–7.5 μ diam., constanti; sporis 16–22 μ, sphaeroideis, obscure brunneis, uniguttulatis, tenuiter echinulatis; echinulis teretibus, truncatis.

Fructifications epigeous, subglobose, 3–5 cm. diameter; surface smooth, somewhat viscid holding particles of soil, white to grayish, drying with some yellowish tints; peridium 1–2 mm. thick, tough and hard, of somewhat gelatinized hyphae, tightly compacted into a hyaline prosenchyma; gleba bone brown, drying the same, compact, powdery, made up at maturity of spores and hyaline and colored hyphae 4–7.5 μ in diam.; spores spherical, 16–22 μ in diam., very dark brown, with a thick epispore, usually with one large vacuole, very finely echinulate, echinulae cylindrical with blunt rounded tips, 6 to about every 4 μ. 1.5 μ long, giving surface appearance of very fine beads.

On decayed granite soil, Prospect, Jackson County, Oregon, *R. A. Pendleton*, June 28, 1925, **type** (in Zeller Herb., *6842*).

CALBOVISTA SUBSCULPTA Morse.

This genus is very close to *Mycenastrum* because of the type of capillitium but it is not like *M. corium* in peridial characters. Morse[12] did not report the species from Oregon but she reported it from Mt. Rainier only in Washington. *C. subsculpta* has been found in four locations in Oregon as follows: Baker County, Cornucopia, July 23, 1941; Clackamas County, on the trail to Paradise Park (Mt. Hood) from Twin Bridges Forest Camp, August 9, 1937; Klamath County, Crater Lake National Park, August 7, 1929; and Lane County, Fairview Mt., near Bohemia (*D. P. Rogers*), July 18, 1937. From Washington we have two collections by *Alex. H. Smith*, Nos. *14726* and *14854*, from Mt. Angeles and Hurricane Ridge, both in the Olympic Mts., and one from Mt. Baker. Dr. Smith also collected it at Lake Fork Ranger Station, Idaho National Forest, Idaho, August 7, 1941.

CALVATIA CRETACEA (Berkeley) Lloyd (FIG. 7)

Lake Harbour, Baffin Island, Canada, *J. Oughton*, Aug. 10, 1939.

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[12] Morse, E. E. A new puffball. Mycologia 27: 96–101. Pls. 12–15. 1935.

There were eleven fructifications of this interesting arctic species, each wrapped separately, but all bearing the above collecting data. The collections were communicated to the writer by Dr. H. S. Jackson, University of Toronto. This material from Baffin Island follows very closely the descriptions of the species furnished by Coker and Couch and by Lloyd, except that the capillitium measures 3.7–7.5 μ. This then is in more perfect agreement with the collections from East Greenland which were described as *C. arctica* Ferdinandsen & Winge. No basidia or sterigmata were found in the Baffin Island specimens. This collection adds one more locality to the circumpolar distribution of *C. cretacea*.

Calvatia subcretacea sp. nov. (FIG. 6)

Fructificationes depresso-globosae, 2–7 cm. crassae, 1.5–4 cm. altae, basi fibrillis albis gracillimis; exoperidio cretaceoalbo vel fumosus, in areolas polygonias pyramidatas circa 7 mm. crassas fisso demumque ex toto evanido; endoperidio tenui furfuraceo, tenaci, melleo, primo integro dein irregulariter dehiscenti; basi sterili inconspicua; gleba primum olivaceo-lutea demum obscure umbrina, pulvere sporarum repleta; capillitio fracto, fusco, 4–12 μ crasso; sporis sphaeroideis, levibus vel minute verrucosis, interdum breve pedicellatis, fuscis, 3.7–6 μ.

Fructifications depressed globose, 2–7 cm. broad, 1.5–4 cm. high, base tapering to a point in young specimens, broad to almost flat when older, lightly attached by white mycelium; ectoperidium chalky white to smoke gray (R), conspicuous because of the polygonal pyramidal warts, the sides of which are mostly marked by lines which converge at the apex, sometimes with parallel lines at various heights around the warts, warts 7 mm. across or smaller, mostly pointed, seldom connivent, with darker apices than the sides, breaking away at maturity to expose a thin, firm, furfuraceous, dull chamois (R) to honey yellow (R) endoperidium, which breaks irregularly above; sterile base scanty or entirely absent, a soft olive buff (R) tissue of small cells; gleba passing through colors from olive buff (R) and drab (R) to a powdery burnt umber (R) mass; capillitium threads fragmented, often forked at about 120°, dark, undulating, sometimes, rough, 4–12 μ in diam.; spores smooth or very finely verrucose, spherical, sometimes with short pedicels, slightly colored to rather dark, 3.7–6 μ.

In duff of fir, hemlock, and spruce under alpine conditions from 6000 to 8500 feet elevation. Idaho, Washington, Oregon, and Northern California. July and August.

SPECIMENS EXAMINED: IDAHO: Boulder Lake (elev. 8300 ft.) near McCall, July 30, 1941, *A. H. Smith*, 15825; Lick Creek Summit, Idaho Nat. Forest, Aug. 2, 1941, *A. H. Smith*, 15930. (Both in University of Michigan Herbarium.)

WASHINGTON: Clallam County, Hurricane Ridge, Olympic National Park, July 7, 1939, *A. H. Smith*, 14860, Sol Duc Park, Olympic National Park, June 20, 1939, *A. H. Smith*, 14489. (U. of Mich. Herb.)

OREGON: Crater Lake National Forest (elev. 6000 ft.), *F. P. Sipe*, July 15, 1929, and July 22, 1943; Hood River County, above Cloud Cap Inn on Mt. Hood, *J. R. Kienholz*, July, 1936, **type**.

CALIFORNIA: Siskiyou County, Mt. Shasta, near Horse Camp (7500–8000 ft.), *Wm. B. Cooke*, Aug. 24, 1937, July 18, July 22, Aug. 12, 1938, July 8, 1940, July 29, Aug. 7, and Aug. 18, 1941, Nos. 8661, 10222, 10238, 10272, 14641, 15650, 15665, and 15742, respectively.

This alpine species has its closest affinities in the arctic species, *Calvatia cretacea*, but differs in several characters as follows: First, the color of the ectoperidium is essentially chalky white instead of creamy or buff, the warts are larger, smoky-dark at the summit, and somewhat contoured by lines (as in *C. arctica*), whereas in *C. cretacea* the warts are concolorous throughout. Second, the endoperidium is dull felty or furfuraceous instead of silvery smooth. Third, the sterile base is usually wanting in *C. subcretacea*.

CALVATIA CYATHIFORMIS (Bosc) Morgan

This species occurs across the country from the Atlantic to the Pacific. We have specimens from high up (7000 feet) in the Wallowa Mts. of eastern Oregon and from the Willamette Valley of western Oregon. Plants we have examined from such more eastern states as Maryland, Ohio, Missouri, and some collections from Texas conform quite closely to the usual original concept of the species. Throughout the west, however, there is considerable variability in the species from almost smooth-spored individuals through forms with very small finely asperate to coarsely verrucose spores. For instance, an extreme case is found in the University of Michigan Herbarium collection No. 1248 taken by *E. A. Smith*, Cisco, Texas, June 23, 1938. The specimens in this collection have the large stalk-like sterile base, the gleba is purplish brown, the spores, however, are finely asperate, short pedicellate, and measure 2.5–4.3 μ including the sculpturing of the epispore. The capillitium is nearly hyaline and measures about 3.75 μ. Externally the plants agree with specimens of *Calvatia cyathiformis,* and we have referred them to that species, although with considerable reluctance. There seem, however, to be plenty of gradations of variability between this extreme variant and the typical forms.

CALVATIA FRAGILIS (Vitt.) Morgan

Coker and Couch have reported this species in northern states from Illinois to Wyoming and from Ontario, Canada. We have studied specimens of it from Texas and Oregon. The Texas collections are mostly the smooth form whereas those from Oregon have areolate peridia. It is the common purple-spored *Calvatia* of western Oregon. Several collections from Oregon were identified by C. G. Lloyd as *C. lilacina* var. *occidentalis* Lloyd, but he questioned whether it differs enough from C. fragilis to warrant the new name. The writer is convinced that the Oregon material is quite typically like that of European *C. fragilis.*

Calvatia fumosa sp. nov. (FIG. 10)

Fructificationes subglobosae vel depresso-globosae, 3–6 cm. crassae, leves vel leniter furfuraceae vel irregulariter rimosae, albae demum fumoso-griseae vel brunneae, basi funiculis albis radicante; peridio circa 1 mm. crasso, duplici sed partibus paene inseparabilibus ab utroque, intus cretaceo-albo, basi sterili vere absenti vel parvulo; gleba pulverulenta, olivacea vel obscure brunnea; capillitio obscure brunneo, fracto, circa 6–18 μ crasso; sporis sphaeroideis, brunneis, verrucosis, breve pedicellatis, 5–7 μ.

Fructifications subglobose to depressed globose, 3–6 cm. in diameter, from a white cord-like rhizomorph; surface smooth to slightly furfuraceous under the lens, sometimes irregularly rimose, white then smoke gray (R) to hair brown (R); peridium drying about 1 mm. thick, of two layers almost inseparable but sometimes quite apparent, chalky white throughout except for the darker surface pellicle; sterile base wanting or merely thin and saucer-shaped, of small inconspicuous cavities with soft partitions; gleba becoming very powdery and completely falling away at maturity, passing through colors from Saccardo's olive (R) to mummy brown (R); capillitium dark brown, straight, unbranched, fragmented, sometimes rough, up to 6–18 μ thick; spores spherical, dark, strongly verrucose, short pedicellate, 5–7 μ.

Under conifers at altitudes of 5000 to 8000 feet on Mt. Shasta, California, and Crater Lake National Park, Oregon.

SPECIMENS EXAMINED: OREGON: Crater Lake National Park, *F. P. Sipe*, July 22, 1943, type.

CALIFORNIA: Siskiyou County, Mt. Shasta, near Everett Memorial Highway, June 27, 1941, *Wm. B. Cooke*, 15522; near head of Panther Creek meadows, July 28, 1941, *Wm. B. Cooke*, 15630; near Horse Camp, Aug., 1944, *Wm. B. Cooke*, 15778; and in Cascade Gulch below Shasta Alpine Lodge, Sept. 7, 1942, *Wm. B. Cooke*, 16799.

The color of this species is quite variable, some collections remaining almost entirely white. A single specimen from Spruce Cove, Trinidad, California, collected by *H. E. Parks*, Aug. 1933 is referred to this species with reservations. It has a much thinner peridium than the other collections. It may prove to be another species when a wide range of specimens are studied.

Calvatia Lloydii Zeller & Coker sp. nov. (FIG. 5)

Fructificationes depresso-globosae vel subturbinatae, basi fibrillis albis radicante, 3–8 cm. crassae, superne tesselatae, cremeoalbae demum stramineae, vel rufobrunneae, inferne furfuraceae parum echinulatae; peridio duplici, sed stratis paene inseparabilibus, irregulariter dehiscenti; exoperidio tenui, areolato; endoperidio tenuissimo, papyraceo; basi sterili cellulosa, concava, purpureo-brunnea; gleba pallide olivacea demum obscure olivaceo-brunnea; capillitio brunneo, fracto, paulo ramoso, 2.5–6 μ crasso; sporis sphaeroideis, pallide brunneis, echinulatis, breve pedicellatis, 3–4 μ.

Fructifications 3–8 cm. in diameter, depressed globose to subturbinate, rounded or flattish above, pinched below and attached by ample, whitish rhizomorphs; surface at first creamy white, becoming stramineous or even reddish brown, dull or at times silky, areolated above into more or less prominent warts or obtuse spines, which are smaller and more or less furfuraceous below; outer peridium rather thin, and broken as described above, not readily separating from the inner peridium which is a papery layer so thin and delicate as to be very obscure and fading almost imperceptibly into the capillitium on the inner side; dehiscence irregular; gleba dusty, cottony mass of capillitium and spores changing from light to dark olive-buff; subgleba concave above extending somewhat in cup form up around the gleba, composed of small lacunae, the partitions thin and purplish brown, with a metallic luster; capillitium 2.5–6 μ, uneven, fragmented, somewhat branched, brown, with occasional linear pits; spores spherical, 3–4 μ in diameter, finely but distinctly echinulate, sometimes spines embedded in a clear envelope, often with torn remains of sterigma.

In dry coniferous duff of the Sierra Nevada Mountains of central California. May to August.

SPECIMENS EXAMINED: California; Stanislaus National Forest, July 28, 1931, *Frank Patty* (U. of Cal. Herb., No. 564470); Sequoia National Park, May 18, 1940, *Robert Wing* (U. of Cal. Herb. No. 698058); July, 1940, *Paul W. Colburn,* No. 4 (U. of Cal. Herb. No. 698060); Headquarters Area of Giant Forest, *Lee Bonar,* July 26, July 27, 1945 (U. of Cal. Herb. Nos. 698063 and 698064); along Halstead Creek trail, near Halstead Meadow, *Lee Bonar,* July 28, 1945, **type** (U. of Cal. Herb. No. 698059); Suwanee Grove, *Lee Bonar,* July 28, 1945 (U. of Cal. Herb. No. 698061); Tulare County, Giant Forest, *T. S. Brandegee,* Aug. 10, 1905, (Lloyd Herb. No. 7300 and U. of Cal. Herb. No. 564436); and Moro Rock Trail, Giant Forest, *Lee Bonar,* July 31, 1945 (U. of Cal. Herb. No. 698062). All of the collections are in the University of California Herbarium. There are parts of some of the collections in the University of North Carolina and the Zeller herbaria.

C. G. Lloyd saw the specimens collected by Brandegee in 1905 and he described them as a new *Calvatia,* but left the species unnamed. See Myc. Writ. 2: letter 18, p. 3. Jan. 1, 1908.) The specimens in the Lloyd Collections are under Catalogue No. 7300. Because Lloyd recognized the species as undescribed we are dedicating it to him, as *Calvatia Lloydii.*

In the fragmented capillitium with elongated pits and in the characters of the peridium, *Calvatia Lloydii* seems nearest *C. caelata,* as suggested by Lloyd. Aside from minor characters, it may be easily separated from that species by the absence of a massive plug-like base, the more slender capillitium with fewer pits, and the echinulate spores. In exterior appearance *C. Lloydii* and *C. tatrensis* Hollos are similar but they differ in size and surface of the spores as well as characters of the capillitium.

Calvatia ochrogleba sp. nov. (FIG. 11)

Fructificationes turbinatae vel depresso-globosae vel irregulares, 7–9 cm. crassae, glabrae vel furfuraceae, sordide rufo-brunnea; peridio duplici sed stratis paene inseparabilibus, strato externo praetenui, strato interno crassiusculo, ochraceo; basi sterili fructificationis quartam inferam occupanti, centro convexula, alba vel subcaerulea; gleba subpulverulenta, firmula, primum lutea demum ochracea; capillitio hyalino, fracto, septato, 4–5 μ; sporis albis, sphaeroideis, asperulis, 5–6.2 μ.

Fructifications turbinate to depressed globose, somewhat misshapen and lobed above, somewhat pointed below, 7–9 cm. broad and high; surface smooth to furfuraceous, dull reddish brown; peridium duplex, outer very thin, not easily separable, the two layers breaking up together, inner medium thick, ochraceous; sterile base about ¼ of fructification, convex above, cavities very small, whitish with bluish tints; gleba of very fine texture but not very powdery and not falling out easily, cavities very small, pale yellow-orange (R) to ochraceous-buff (R); capillitium hyaline, fragmented, septate, not pitted, 4–5 μ; spores creamy white, spherical, finely asperate, 5–6.2 μ.

In meadow, Aurora, Marion County, Oregon, *Edwin Netter*, Sept. 18, 1941, **type.**

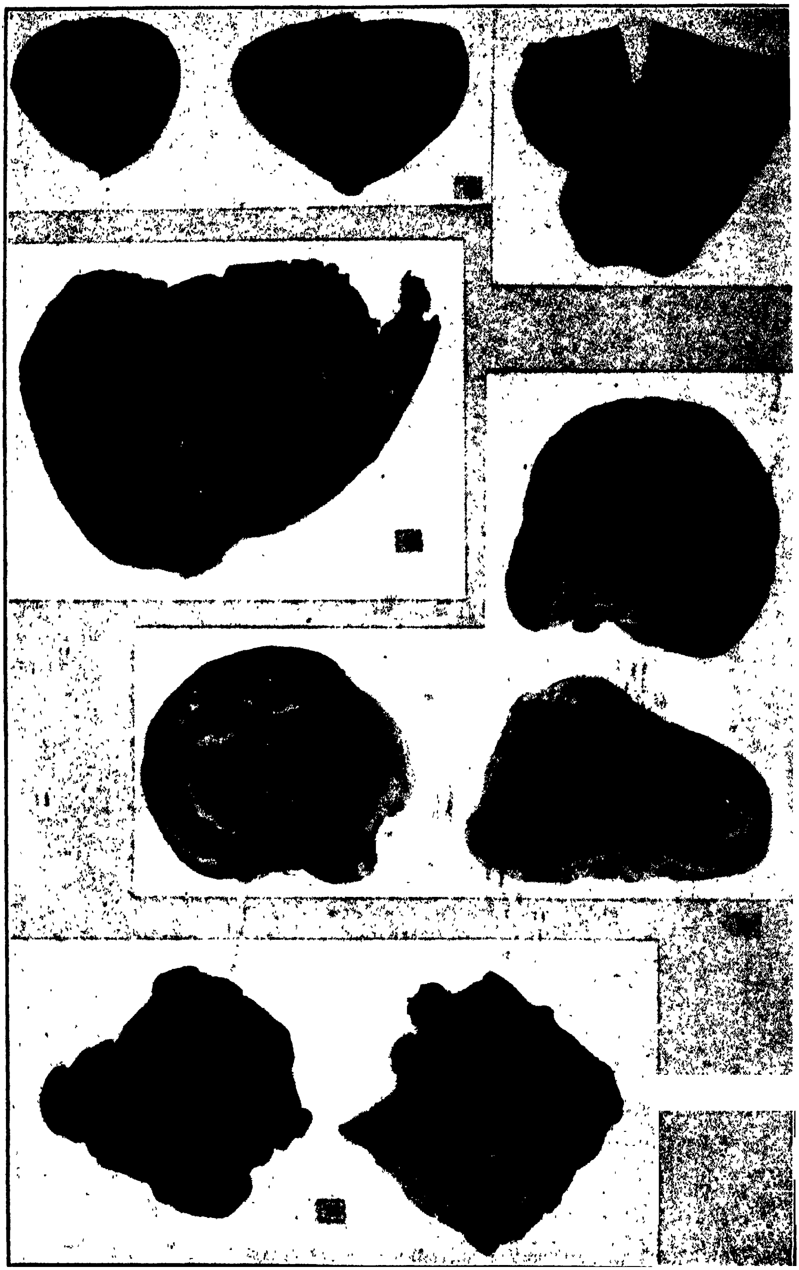
This is a very distinct species in many characters, especially in the color and texture of the gleba and the bluish color of the tissues of the sterile base.

Calvatia rubrotincta sp. nov.

Fructificationes depresso-globosae, 4–7 cm. crassae, 3–4 cm. altae, inferne sulcatae, basi fibrillis albis radicante, inferne glabrae vel stuppeae vel furfuraceae, superne tessellatae, albae demum rubro-maculatae; peridio duplici, exoperidio albo, tenuissimo, evanido vel squamuloso persistanti, endoperidio crassiusculo fragili, irregulariter dehiscenti; basi sterili cellulosa, fructificationis decimam inferam occupanti, in centro paullo elevata, alba vel purpureo-brunnea; gleba pulverulentissima, benzo-brunnea vel obscure vinaceo-cinerea; capillitio obscure brunneo, paulo ramoso, fracto, 3–4 μ; sporis sphaeroideis, obscure brunneis, maxime verrucosis, breve pedicellatis, 5–6.2 μ.

Fructifications depressed globose, 4–7 cm. broad, 3–4 cm. high, sulcate below, from a base with several white cord-like rhizomorphs; surface smooth to felty or furfuraceous below, areolated above by wrinkled reticulations, Hay's brown (R) when covered with spores, whitish where exoperidium has not disappeared, staining red in spots; peridium duplex, outer layer white, very thin, evanescent, or a mere flaky cover, inner layer somewhat thicker, brittle, easily broken up along the ridged reticulations; sterile base about $\frac{1}{10}$ of fructification, convex above, soft, large-celled, white to purplish brown, metallic luster where torn; gleba very powdery, benzo brown to dark vinaceous-drab (R); capillitium dark brown, not pitted, not much branched, fragmented, 3–4 μ in diam.; spores spherical, 5–6.2 μ, dark, deeply verrucose, short pedicellate, many long pedicels floating free.

Under *Pinus ponderosa*, south of Silver Lake near Mt. Hager, Lake County, Oregon, *W. E. Lawrence*, July 23, 1934, **type.**



FIGS. 8–11. Interesting Gasteromycetes.

Calvatia subpratense (Lloyd) Coker & Zeller n. comb. (FIG. 8)

Syn.: *Lycoperdon subpratense* Lloyd, Myc. Writ. 2: 231. *pl. 62, f. 1–7.* 1905.

Fructifications depressed globose or turbinate, bowl- or urn-shaped at maturity, 2.5–5 cm. high, 2–4 cm. broad; surface white, then pale ochraceous buff (R) or flesh pinkish, becoming shades of olivaceous or finally a dark shining metallic brownish where the inner peridium is exposed; outer peridium composed of small soft spines somewhat united at the apex, mixed with tiny simple spines and furfuraceous granules, which fall away from mature specimens; inner peridium thin, dark, inner surface at first densely felted with bases of capillitium threads but becoming shiny and metallic in old specimens, dehiscing by more or less stellate lobes which break up and fall away until the upper portion of the peridium has disappeared; sterile base prominent, of large cells, white, then brownish or purplish, often forming the whole lower half of the fructification, cup-shaped, separated from the gleba by a definite diaphragm, which is membranous and left smooth, shining, and metallic in old specimens; gleba white soft, becoming yellowish olivaceous, then light brownish olive; capillitium scanty at maturity, attached to the entire inner surface of the peridium and the diaphragm, pale brown, even or slightly irregular, up to 4 μ in diameter, sparingly branched, the walls moderately thick, not pitted, breaking up into short sections; spores spherical, smooth, dilute olivaceous, 3.2–4.7 μ.

In lawns and pastures. Massachusetts and Pacific Coast states.

SPECIMENS EXAMINED (by one or both of us): MASSACHUSETTS: Essex County, Peabody, *R. B. Mackintosh* (C. G. Lloyd Cat. No. 13207); Middlesex County, Cambridge, *A. B. Seymour,* **type** (C. G. Lloyd Cat. No. 51437). WASHINGTON: Klickitat County, Bingen, *W. N. Suksdorf* (in C. G. Lloyd Coll.). OREGON: Benton County, Corvallis, *H. C. Gilbert,* Nov. 19, 1915 (in O.S.C. Herb. 7146), *Roderick Sprague,* Oct., 1930 (in O.S.C. Herb. 7792), *S. M. Zeller,* Aug. 9, 1919, Oct. 19–25, 1937, July 7, Aug. 14, Nov. 17, 1939, May 8, 1940; Clackamas County, Canby, *S. M. Zeller,* Oct., 1926; Douglas County, Glide, *S. M. Zeller,* June 14, 1937; Marion County, *S. M. Zeller,* Oct. 14, 1926; Multnomah County, Gresham, *S. M. Zeller,* Nov. 18, 1927; Yamhill County, Newberg, *S. M. Zeller,* Oct., 1926; Washington County, Scholls, *S. M. Zeller,* Sept., 1937.

Calvatia subpratense is the most common puffball occurring in lawns and pastures in western Oregon. It has a tendency to grow in "fairy rings" in lawns, stimulating the growth of grass in the circumference of the rings but not doing the damage to grass occasioned by *Marasmius oreades*.

This species, as already stated by C. G. Lloyd, answers quite well the description of *Lycoperdon pratense* Pers. but until such time as we may be able to prove just what Persoon's *L. pratense* is, it seems best to us to retain Lloyd's specific name for the American plant but to transfer it to the genus *Calvatia*.

It is puzzling what becomes of the capillitium during maturation, as it is definitely scanty in the ripe condition although the peridium and diaphragm show a dense coating of capillitium bases. It must be that the bases of the threads are less subject to autolysis than the main portion of the threads after they break away.

Abstoma Townei (Lloyd) n. comb.

Syn. *Catastoma Townei* Lloyd, Myc. Notes **67**: 1168. July, 1922; **68**: 1175. *pl. 228, fig. 2337.* Jan., 1923.

EMENDED DESCRIPTION: Fructifications subglobose, drying 2.5 cm. broad and 3 cm. high, universal veil dull drab, flocculent, breaking up as in Amanitas, leaving small flecks and patches over the surface of the ectoperidium which otherwise is smooth, very slightly viscid, Sanford's brown (R) to slightly lighter, thin, brittle, breaking away as in *Bovista;* endoperidium thin, whitish; gleba with tints of yellow and purplish when young, firm and compact though pulverulent; capillitium thin-walled, tinted slightly yellowish; spores spherical, deeply verrucose, purplish brown, pedicellate, 7.5–12.5 μ in diameter.

On ground. California.

SPECIMENS EXAMINED: **Type** collected by *Stuart S. Towne* (in Lloyd Myc. Collections, No. 31027).

The type collection consists of one young specimen, which is entirely inadequate for diagnosis, but since it bears a name, an effort should be made to retain it if possible until adequate material of the species is discovered. As Lloyd suspected, it does not belong in *Catastoma*. It undoubtedly belongs in *Abstoma* although the universal veil is not as much of a "sand case" as found in some other species of this genus.

The upper part of the gleba matures first and the only mature portion in the type specimen is centrally located in the top part. It is purplish and is surrounded by a yellowish, less mature portion. The basal portion is still whitish and made up almost entirely of capillitium, much as that observed in *Disciseda Uplandii* (Lloyd) Zeller.

Disciseda ater (Lloyd) n. comb.

Syn. *Catastoma ater* Lloyd, Myc. Writ. *5*: Note No. 53: *756–757. f. 1131.* Feb. 1918.

EMENDED DESCRIPTION: Fructifications subglobose, 3 cm. in diameter (dry), black; ectoperidium black, shiny, very thin, breaking away irregularly leaving the light-colored endoperidium exposed in spots or angular patches; endoperidium dull, light clay color, thickish and of the consistency of an oak gall, dehiscing by a large, slightly mammose, apical stoma; gleba pulverulent, mummy brown (R); capillitium brownish, 3.7–5 μ in diameter, irregular, heavy walled, fragmented, slightly branched; spores subglobose to ovoid, apiculate, brown, smooth to asperulate, one large vacuole, 3.75–5 μ in diameter.

In a dry gravel wash, San Gabriel watershed, Cow Canyon, Los Angeles County, California, Sept. 17, 1917, *I. M. Johnston*, No. 2, **type** (in Lloyd Myc. Collection, No. 33650).

It is unfortunate that throughout Lloyd's description and notes on this species he has referred to both the ectoperidium and endoperidium as "endoperidium." It is only by examination of the type specimen that one may straighten out his notes. It is hoped this is adequately corrected in the above emended description. Surely Cunningham did not have access to the type collection when he erroneously placed *D. ater* in synonymy with *D. candida.* There is nothing about the two that is similar and they could hardly be confused. The fructification of *D. ater* has the general appearance of a black weathered oak gall. There is no sand case; in fact, the ectoperidium is a closely adhering, thin, shell-like layer.

Disciseda Brandegeei (Lloyd) n. comb. (FIG. 3)

Syn. *Catastoma Brandegeei* Lloyd, Myc. Writ. **5** (Letter 65): 7. March, 1917; **6**: 897–898. *pl. 137. f. 1576.* Oct. 1919; **7**: 1168. July 1922.

EMENDED DESCRIPTION: Fructifications globose or depressed globose, 1.5–3.5 cm. in diam.; exoperidium thin, peeling away from the endoperidium in thin shell-like flakes, not forming a cup, smooth and with a silky sheen, or drying dull, usually pale or sordid whitish, but sometimes with buff or even brownish tints; endoperidium thin, smooth, deep olive-buff (R) or with pale slaty appearance, sometimes with lacerated plane aperture below at point of attachment of fructification; gleba at first white to smoky white then wood brown (R), avellaneous (R), buffy brown (R), or even Dresden brown (R) at maturity; capillitium pale to yellowish brown, slightly branched at right angles, broken, 2.5–5 μ not pitted; spores globose, 5–8.6 μ, brown, smooth.

In open areas in dry barren soil. Summer. Texas to California and Mexico.

SPECIMENS EXAMINED: MEXICO: Sinaloa, Culiacan, *T. S. Brandegee*, 1904, **type** (in C. G. Lloyd Myc. Coll. No. 37840); Texas, Eastland County, Cisco, *E. A. Smith*, July and August, 1938, Nos. 1210, 1218, 1234, 1237 (in Univ. Mich. Herb.).

The type collection is much darker brown than most of the Texas material, which numbers about 90 specimens. The dark exoperidium of the type collection, containing one specimen, is of such a dark brownish color as to suggest it might have been too severely handled or not naturally dried.

The basal dehiscence of the endoperidium is seldom apparent. The basal rhizomorph originates in the endoperidium, thus penetrating the ectoperidium. When the rhizomorph breaks away from the endoperidium it may or may not leave an aperture to the gleba. There is no indication of an apical stoma.

The one other species with smooth spores, *D. levispora*, is quite different from *D. Brandegeei*, in size of spores and peridial characters.

Disciseda defodiodis (Lloyd) n. comb. (FIG. 1)

Syn. *Calvatia defodiodis* Lloyd, Myc. Writ: 4 (Letter 44): 8. Jan., 1913.

Fructifications oblong to turbinate, usually truncate above, 2–3 cm. high, 0.8–2 cm. broad, with a rooting-rhizomorph; sterile base none; peridium duplex; outer layer thin, white, soft, of loosely interwoven hyphae, usually left as a cup around the lower half of the fructification; inner layer thin, but hard and white like the shell of reptilian eggs, sometimes hard when dry, tough but splitting most readily along vertical lines, dehiscing circumscissilely or by ruptures radiating from the basal point of attachment after liberation from the ectoperidial cup; gleba pulverulent, pale olive, drying deep olive buff (R); capillitium cobwebby, branched, flaccid, subhyaline, thin-walled, rarely with rounded protuberances, much broken, 3.75–5 μ in diam.; spores subglobose to ovoid, sometimes somewhat angular, subhyaline, smooth, rarely very finely asperate under high power lens, 3.75–5 μ in diam.

Imbedded in soil with top about even with surface of ground. Late June to summer, North Dakota and Wyoming.

SPECIMENS EXAMINED: NORTH DAKOTA: Lamoure County, Kulm, *J. F. Brenckle,* June 24, 1923 (in C. G. Lloyd Myc. Coll., No. 22362); Morton County, near Mandan, *R. Sprague,* June 10, 1942 (in Zeller Herb.). WYOMING: Park County, Meeteetse near Cody, *Simon Davis,* **type** in C. G. Lloyd Myc. Coll., No. 22361).

This species is an oddity in that an unbroken endoperidium might at first be mistaken for the egg of a reptile. It recalls to the writer's mind the occasion when he received from a botanical colleague reptilian eggs for identification as a gasteromycete.

Disciseda Johnstonii (Lloyd) n. comb.

Syn. *Catastoma Johnstonii* Lloyd, Myc. Notes **61**: 898. Oct., 1919; **67**: 1168. July, 1922.

EMENDED DESCRIPTION: Fructifications depressed globose, about 1.5 cm. in diam.; ectoperidium thick, flaking away leaving a mere disk at the base, dark brown, rough; endoperidium thin, pliable checked by tiny cracks into angular areas, dehiscence not evident; gleba reddish brown, powdery, flocculent; capillitium very light yellow, wavy, with heavy walls, somewhat branched, broken, 3.5–4 μ in diameter; spores globose to angular, verrucose, 4–5 μ, yellowish, sometimes short-pedicellate.

At side of trail in chaparral belt, upper Sonoran Zone, alt. 3000 feet, Cucamonga Canyon, *I. M. Johnston,* No. 238, Nov. 10, 1918, **type** (in Lloyd Myc. Collection, No. 33647).

Lloyd described the spores as smooth although in the type they are quite verrucose, at least much more so than are those of *D. candida.*

Disciseda levispora (Lloyd) n. comb.

Syn. *Catastoma levisporum* Lloyd, Myc. Notes **59**: 853. *f. 1428.* **67**: 1168. July, 1922.

EMENDED DESCRIPTION: Fructifications 2.5–3 cm. in diameter, subglobose; sterile base none; peridium firm cartilaginous; ectoperidium thick, firm, smooth, dark brownish to blackish, not easily separable from the endoperidium which is papery thin, whitish, dehiscing almost stellately at the apex; gleba dark purplish, brown, powdery and flocculent; capillitium wavy, heavy walled, pale brown, slightly branched at right angles, broken, 6–8 μ diam.; spores spherical, smooth, 3.5–4.5 μ, short pedicellate.

On ground in vacant lot under pepper trees, Claremont, California.

SPECIMENS EXAMINED: CALIFORNIA: Los Angeles County, Claremont, *Lois M. Clancy*, Oct. 9, 1916, **type** (in Lloyd Myc. Collection, No. 8782).

The type collection is quite inadequate, being the fragmentary portion of one fructification. It is hoped the collection reported later by Lloyd as taken by *I. M. Johnston* (Myc. Notes **67**: 1168. 1922) is more representative.

Disciseda luteola (Lloyd) n. comb.

Syn. *Catastoma luteolum* Lloyd, Myc. Writ. **2**: Letter 11: 4, June, 1906; **7**: 1168. July, 1922.

EMENDED DESCRIPTION: Fructifications depressed globose, about 1.5–2 cm. broad, drying stramineous to clay-color; ectoperidium very thin, furfuraceous, fugacious; endoperidium thin, flaccid, papyraceous, buffy to cream color below, light brownish above, dehiscing at basal point of attachment through torn aperture; gleba buffy brown (R) to olivaceous, pulverulent; capillitium irregular, heavy walled, very slightly branched, pale yellow, fragmented, about 3–4 μ; spores spherical, almost smooth but somewhat verruculose, apiculate, 5–6.5 μ.

On the ground. Tahoe Lake, California. July.

SPECIMENS EXAMINED: CALIFORNIA: Lake Tahoe, *P. B. Kennedy*, July, 1905, **type** (in Lloyd Myc. Collection, No. 37839).

Lloyd's observation that this species is close to *Disciseda hypogaea* (Cooke & Massee) Cunn. is accepted but the two are quite distinct in the epispore markings and in the dehiscence of the endoperidium.

Disciseda uplandii (Lloyd) Zeller n. comb.

Syn. *Catastoma Uplandii* Lloyd, Myc. Notes **61**: 897. *pl. 137 f. 1575,* Oct., 1919; **67**: 1168. July, 1922.

EMENDED DESCRIPTION: fructifications depressed globose 1.5–2 cm. in diameter, purplish brown when dry; exoperidium thin, rough with adherent sand, persisting over the lower half of the fructification; endoperidium thin, papery, slaty-brown, dehiscing by a torn apical pore; gleba buffy brown (R) to drab (R), pulverulent, nearly all capillitium in lower part, with very few spores, spores plentiful above; capillitium irregular, wavy, somewhat branched at right angles without septum, walls heavy, slightly pitted, brown, 3–4 μ diameter; spores spherical, 6–7.5 μ, dark brown, verrucose, with short remains of the sterigma which is proportionately broad (at least 1.2–1.7 μ broad).

In open grassy ground, altitude 1200 feet, Upland, California. December.

SPECIMENS EXAMINED: CALIFORNIA: San Bernardino County, Upland, *I. M. Johnston,* Dec. 25, 1918, No. 286 **type** (in Lloyd Myc. Coll., No. 8785).

This species is characterized by the very rough, verrucose spores, which have a short but conspicuously broad pedicel or apiculus and by the tendency toward a sterile base. Lloyd's "very minute apiculus" was not found. The capillitium is very compact in the lower part of the gleba with very few if any spores, except those that accidentally moved in as the fructification was vertically sectioned. Some microscopic mounts from this part of the fruiting body had no spores in them. This sterile basal portion made up entirely of capillitial filaments is novel among the Lycoperdaceae.

D. uplandii also differs from other species of the genus in the *pitted* capillitium, which Cunningham[13] states definitely is not a character of *Disciseda.* This anomalous species recalls somewhat the gleba of the Mesophelliaceae[14] and the Geastraceae.

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[13] Cunningham, C. H. Gasteromycetes of Australia and New Zealand. John McIndoe, printer, Dunedin, N. Z., 1942 (see pp. 135–136).

[14] Zeller, S. M. Representatives of the Mesophelliaceae in North America. Mycologia **36**: 627–637. *illus.* 1944.

EXPLANATION OF FIGURES

(All specimens except fig. 11 natural size)

FIG. 1. Four fructifications of *Disciseda defodiodis* (Lloyd) Zeller. One and four show the ectoperidium broken away exposing the endoperidium above. Two and three are endoperidia broken from the basal portion by circumscissile rupture.

FIG. 2. Two dried fruiting bodies of *Calvarula excavata* Zeller in which the location of sutures of the tramal peridium is revealed as ridges.

FIG. 3. Two specimens of *Disciseda Brandegeei* (Lloyd) Zeller illustrating the rupture of the exoperidium. In the first specimen the ectoperidium is torn away exposing the basal pore in the endoperidium.

FIG. 4. Median section of a dried specimen of *Macowanites alpinus* Zeller.

FIG. 5. *Calvatia Lloydii* Zeller & Coker. Specimen above shows irregular dehiscence; specimen below somewhat less mature.

FIG. 6. Two fructifications of *Calvatia subcretacea* Zeller. Specimen above shows dehiscence of both the ecto- and endoperidium. Specimen below illustrates younger stage and character of the ectoperidium.

FIG. 7. Three specimens of *Calvatia cretacea* (Berkeley) Lloyd illustrating peridial characters in comparison to those of *C. subcretacea* (fig. 6).

FIG. 8. Three fructifications of *Calvatia subpratense* (Lloyd) Coker & Zeller, the first showing irregular apical dehiscence of a small specimen; the second, a median vertical section showing gleba and sterile base; the third, an old overwintered specimen.

FIG. 9. *Calvatia tatrensis* Hollós (see Mycologia 33: 213. 1941).

FIG. 10. Three specimens of *Calvatia fumosa* Zeller showing the smooth peridium, its irregular cracking, and gleba with little or no sterile base.

FIG. 11. Exterior and interior of *Calvatia ochrogleba* Zeller. × ½.

FUNGI CAUSING DECAY IN WOODEN BOATS

Ross W. Davidson, Frances F. Lombard,[1] and Ray R. Hirt[2, 3]

(with 4 figures)

In a survey of decay in boats (5), started in 1941, an attempt was made to isolate and identify the fungus involved in each case investigated. Decay fungi were obtained from about one-third of the samples from which isolations were attempted. In many instances the fungus was inactive in the selected wood sample or molds had invaded the decayed wood so completely that the fungus causing the damage could not be isolated. In some samples the fungus obtained may not have been the cause of the principal damage but in general those fungi recovered most frequently are believed to be among the more important species causing decay. Certain fungi, such as *Poria incrassata* (Berk. & Curt.) Burt, which die rather quickly on drying (10), probably were involved in some cases of extensive damage although they were not identified during this limited survey. A more exhaustive study would result in obtaining additional species.

TYPES OF ROT ENCOUNTERED

Most of the decays in wooden boats, as in buildings, are of the brown carbonizing type. The ratio is different from that usually encountered in living or dead trees in the forest where white and brown rots occur in about the same proportion.

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[1] Pathologist and Assistant Pathologist, respectively, of the Division of Forest Pathology, Bureau of Plant Industry, Soils, and Agricultural Engineering, U. S. Department of Agriculture.

[2] Professor, Department of Forest Botany and Pathology, The New York State College of Forestry, Syracuse, New York.

[3] The authors are indebted to many individuals for collecting and sending in samples of decay.

During the present survey there were no important white rots found in softwood boat timbers but some were encountered in those of hardwoods. *Polyporus versicolor* Fr. was isolated from mahogany sapwood twice and was found fruiting on another specimen. *P. pargamenus* Fr. was isolated once from beech. Both of these fungi were present mainly because non-durable wood had been used. The white pocket rot, caused by *Stereum frustulosum* Fr., was the only important boat decay that would be placed in this group. It is one of the most important oak heart rots (4) and its common presence in oak boat timbers may have been due in part to the use of wood already infected.

The numerous brown rots are very much alike in appearance and usually they cannot be identified except from associated fruiting bodies or by studying the isolated organisms in pure culture. A number of the brown rots (Table 1) were obtained from both hardwoods and softwoods, notably those caused by *Poria microspora* Overh. and *P. xantha* (Fr. ex Lind) Cke. Although many fungi are known to invade both hardwoods and softwoods, some dual invasions were undoubtedly caused by the fact that in boat construction both types of wood are commonly used in close association.

Table 1 indicates the type of rot and kind of wood involved in each decayed specimen from which a fungus was obtained.

FUNGI ISOLATED FROM BOAT DECAY

It early became apparent that identification, by means of cultures, of most of the important species would be difficult. The initial difficulty was due in a large part to the fact that the most frequently isolated species, *Poria microspora* (FIG. 1, *G* to *I*), had not been described at that time. Cultures that bore the name *Trametes serialis* Fr. and were similar to the boat-decay fungus were not regarded as properly belonging in that species. Spore cultures from a poroid fruiting body proved to be the same as this common fungus but the sporophore was not identifiable. L. O. Overholts suggested that it might be the same as a fungus being studied by Miss M. K. Nobles and an exchange of cultures showed that the fungi

TABLE 1
DATA ON FUNGI ISOLATED FROM DECAY IN WOODEN BOATS

Fungi	Type of Decay	Number of Specimens	Kind of Wood	Part of Boat Affected			
				Hull	Deck	Framing Timbers	Others[1]
Poria microspora Overh.	Brown	23	Fir[2] 10, pine 5, oak 5, cypress 2, white cedar 1	11		5	7
Poria xantha (Fr. ex Lind) Cke.	do.	21	Pine 8, fir 6, oak 5, spruce 1, mahogany 1	5	5	6	5
Poria oleracea Davidson & Lombard	do.	12	Oak 11, mahogany 1	2		9	1
Daedalea quercina L. ex Fr.	do.	9	Oak 6, mahogany 1, pine 1, other 1	3	2	2	2
Lenzites saepiaria Wulf. ex Fr.	do.	7	Pine 6, fir 1	1	5		1
Poria carbonica Overh.	do.	7	Fir 5, other 2	2	1	1	3
Stereum frustulosum Fr.	White pocket	7	Oak 7	1	1	5	
Lenzites trabea Fr.	Brown	4	Pine 2, Mexican mahogany 1, fir 1		2		2
Fomes roseus (Fr.) Cke.	do.	2	White cedar 2	2			
Lentinus lepideus Fr.	do.	2	Pine 2	1	1		
Polyporus versicolor Fr.	White	3	Mahogany (sapwood) 2, elm 1	1	1		1
Unidentified fungus (producing strong odor)	Brown	2	Fir 1, oak 1	2			
Coniophora cerebella Pers. (*C. puteana* (Schum. ex Fr.) Karst.)	do.	1	Oak 1				1
Hydnum erinaceus Fr.	White	1	Beech 1			1	
Merulius tremellosus Fr.	do.	1	Oak 1			1	
Polyporus pargamenus Fr.	White	1	Beech 1	1			
Polyporus sulphureus Fr.	Brown	1	Oak 1				1
Polyporus palustris Berk. & Curt.	do.	1	Pine 1		1		
Poria nigra Berk.	do.	1	Oak 1		1		
Trametes serialis Fr.	do.	1	Fir 1				1
Miscellaneous unidentified fungi	Undetermined	8	Pine 3, mahogany 2, fir 1, undetermined 2		1	1	6

[1] Mostly chines, hatch coverings, fenders, and masts.
[2] Fir as used here is mostly Douglas-fir.

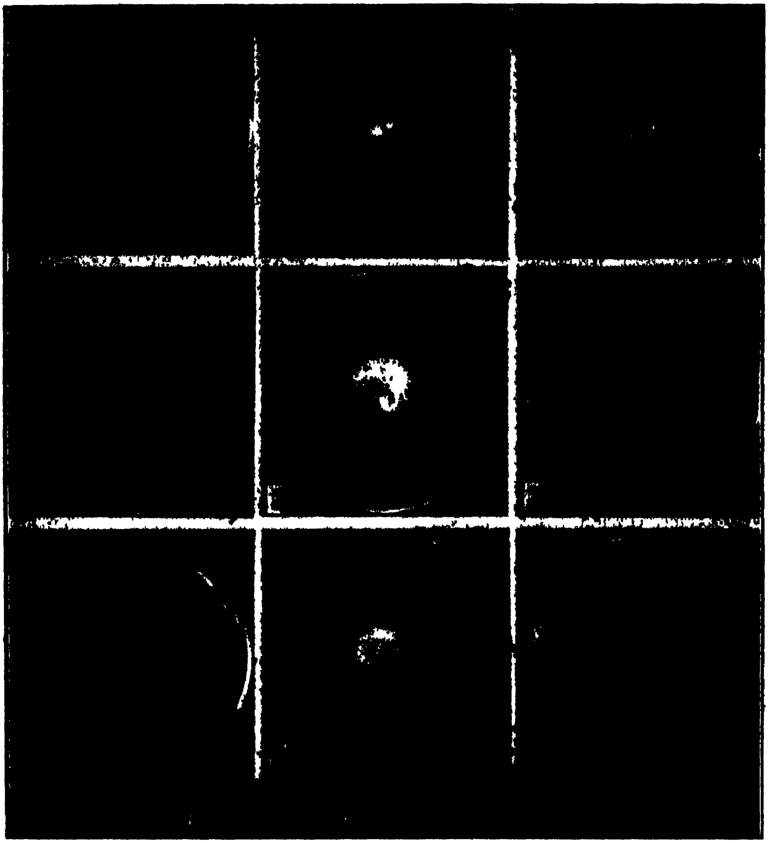

FIG. 1. One-week-old cultures of boat decay fungi grown on 2 per cent malt agar at room temperature. *A*, *Fomes roseus*; *B*, *Lentinus lepideus*; *C*, *Lenzites saepiaria*; *D*, *Lenzites trabea*, *E*, *Poria oleracea*; *F*, unidentified, odoriferous fungus; *G* to *I*, *Poria microspora*; *G*, isolate No. 106 from Douglas-fir decay in yacht "America"; *H*, Madison isolate No. 575; *I*, isolate from Douglas-fir log in Oregon.

were the same. It was described as *Poria microspora* Overh. in 1943 (6).[4]

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[4] In a paper that appeared since this manuscript was written, L. O. Overholts (Mycologia 38: 674–675. 1946) presents evidence to show that his *Poria microspora* is a synonym of *Poria monticola* Murrill. A part of the type specimen of *P. monticola* (Weir No. 61) in the Bureau of Plant Industry herbarium at Beltsville, Maryland, appears to be the same as *Poria microspora* and is the best specimen of this fungus we have seen.

At the same time that *Poria microspora* was being studied, another species was causing similar confusion. The cultures seemed quite similar to those of *Fomes officinalis* Vill. ex Fr., but in several instances fragments of poroid fruiting bodies were attached to the decayed wood. These cultures when compared with available *Poria* cultures were identified as the new species *Poria carbonica* Overh. (6).

The species *Poria xantha* was occasionally found fruiting in typical condition but cultures of it are so variable that classification on the basis of cultures alone was sometimes difficult. The mycelium in some of the cultures had very little color, and in others developed considerably more slowly than in the typical ones.

Most of the species listed in Table 1 also occur under forest conditions. Those that are primarily oak-decay species, such as *Poria* sp. (herein described as *Poria oleracea* sp. nov.), *Daedalea quercina* L. ex Fr., and *Stereum frustulosum*, are known to cause heart rots (4). Those that occur most frequently in softwood, such as *Poria microspora*, *P. xantha*, and *P. carbonica*, are not known to be important in living trees.

Those fungi which have been described previously from cultures (2, 4) and several of the more important ones studied by Nobles (6) have not been redescribed here. Besides occurring in living oak and in ship timbers, *P. oleracea* (previously described as *Poria* sp. (4)) was also isolated by Roth (9) from oak ties and undoubtedly is a fairly common fungus although it has not been possible to refer it to any of the previously known species. The methods employed in studying the cultures and the arrangement of the descriptions in this paper are similar to those given previously (4).

Poria oleracea Davidson and Lombard n. sp.[5] (FIG. 1, *E*; FIG. 2, *A*; FIG. 3)

Pori in areas 3–6 mm. latas in ligno quercino in ampullis evolventes, delicautli, dissepimentis tenuibus praediti, magnitudine formaque irregularies, 2–3 per mm., 1–4 mm. longi, pallide alutacei usque vetusti et deteriores cervini, in siccitate contracti; basidia 9–13 × 4–6 μ; basidiosporae 5–7 × 2–3 μ, hyalinae, aculeolatae; chlamydosporae in substratu abundantes, late ovoideae, 5–10 × 3–6 μ, leves, hyalinae.

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[5] The Latin description was prepared by Edith K. Cash, Associate Mycologist, Division of Mycology and Disease Survey, Bureau of Plant Industry, Soils, and Agricultural Engineering, U. S. Department of Agriculture.

Pores developing in small patches (3–6 mm. or more across) on oak wood in flasks, delicate and thin-walled, irregular in size and shape, 2–3 per mm., 1–4 mm. long, "light buff"[6] to "tawny" when

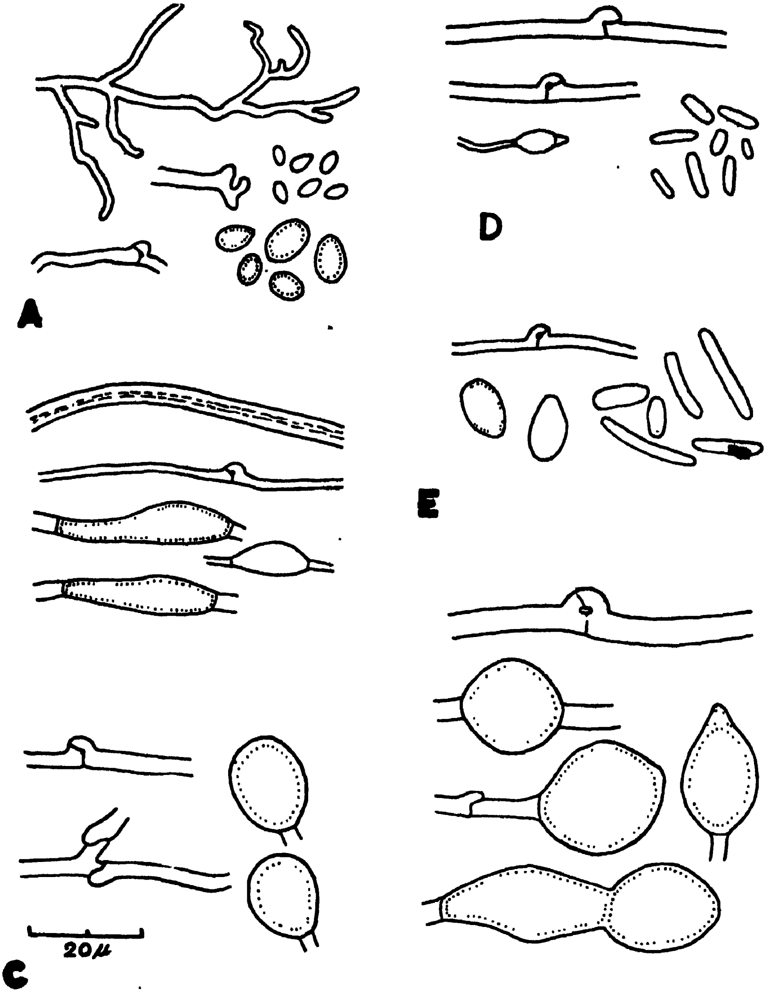

FIG. 2. *A, Poria oleracea:* hyphae, chlamydospores, and basidiospores. *B, Fomes roseus:* hyphae and chlamydospores. *C, Lentinus lepideus:* hyphae and chlamydospores. *D, Lenzites saepiaria:* hyphae, thin-walled chlamydospore, and oidia. *E, Lenzites trabea:* hypha, thin-walled chlamydospores, and oidia. *F,* unidentified fungus: hypha and chlamydospores.

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[6] Colors in quotation marks according to Ridgway (8).

old and deteriorating, shrinking considerably on drying; basidia 9–13 × 4–6 μ; basidiospores 5–7 × 2–3 μ, hyaline, somewhat pointed at ends; chlamydospores abundant in substratum, broadly ovoid, 5–10 × 3–6 μ, smooth-walled, hyaline.

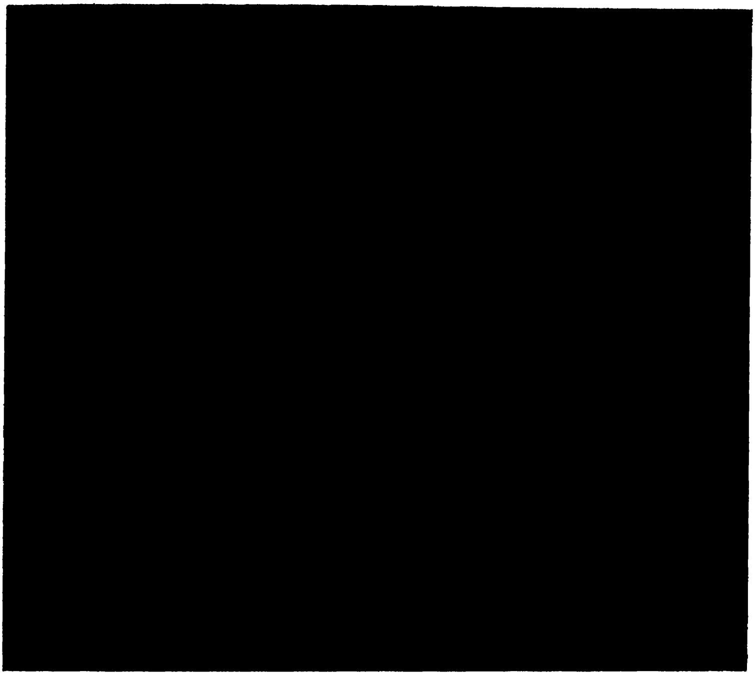

FIG. 3. Sporophore of *Poria oleracea* developed on sterilized oak wood in flask.

Type sporophores (F. P. No. 48282), developed on white oak wood in flasks from cultures isolated from rot in oak, deposited in the Mycological Collections of the Bureau of Plant Industry, United States Department of Agriculture.

Key pattern.[7]—A–O–M–1–2–5–6–10

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[7] The key pattern has been explained previously (4, pages 9 to 13). The first letter represents color of mat (A, white; B, white, then yellow or brown; C, yellow, etc.). The second letter of the key pattern represents positive (P) or negative (O) oxidase reaction. The third letter indicates growth rate. The numbers indicate presence of certain microscopic features such as clamps, chlamydospores, conidia, etc. The key pattern is useful in arranging the fungi, based on their characteristics in culture.

Growth characteristics.—Growth medium, forming a mat 7 to 8.5 cm. diameter in fourteen days; mat short cottony to floccose cottony, usually zonate, and occasionally forming definite sectors; fragile, thin (agar showing through), white or rarely with a slightly yellowish area about the center; nodulose, waxy patches develop on the surface mycelium, at times abundant before fourteen days, but usually requiring a longer time to form, often producing basidia and basidiospores; margin proper white, floccose cottony, even; odor that of rotten cabbage in old cultures; negative oxidase reaction.[8]

Hyphal characteristics.—Staining hyphae of two kinds, one 1–5 μ diameter, with simple clamps, much-branched, the other 4–8 μ diameter, smooth, little-branched, with simple and multiple clamps, becoming thick-walled, hyaline on aging, often with clublike ends where clamps have broken; chlamydospores 5–10 × 3–6 μ, ellipsoid, with medium-thick hyaline walls, very abundant, in old cultures surface mycelium practically all turned into chlamydospores; basidia formed in the nodulose patches on surface sometimes fairly abundant in fourteen days.

Temperature relations.—Optimum approximately 30° C. Average mat diameters in seven days in the dark at constant temperatures follow: 2.4 cm., 20°; 3.9 cm., 25°; 5.4 cm., 30°; 4.8 cm., 35°; 0, 41° C.

Test-tube cultures.—In twenty-eight days mat appressed, fragile, pulverulent to floccose or somewhat nodulose, white, often with raised waxy patches on upper part of slant that develop into shallow pores; glass opposite slant coated with a feathery or cottony mycelium; poroid fruiting in small patches on upper part of agar slant and on glass opposite slant, at first merulioid, later definitely poroid with pores irregular in shape and size, mostly small (0.3 mm.) but with thick walls and remaining fairly shallow; "light buff" to "pinkish buff" in color with brown developing at margins where drying occurs; spore print white, often forming on side of test-tube opposite poroid areas; basidia oblong, 9–13 × 4–6 μ with four sterigmata; basidiospores 5–7 × 2–3 μ, elongate with somewhat pointed ends, hyaline.

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[8] Fungi causing brown carbonizing rot in wood usually give no reaction when grown on agar containing gallic or tannic acid whereas white rot fungi cause a dark color reaction when grown on such media (3).

Type of decay.—Brown rot in oak heartwood. Isolated twelve times from boat-decay specimens, one of which was from mahogany wood.

Remarks.—This species was isolated thirteen times from oak heart rot specimens (4) and several times from oak ties by Roth (9). It is somewhat similar to *Polyporus compactus* Overh. (4, 7) in the abundant chlamydospore development but is different in other respects. Sporophores develop readily on oak blocks in flask cultures, especially on the glass where the block touches the side of the flask.

FOMES ROSEUS (Fr.) Cke. (FIG. 1, *A*; FIG. 2, *B*)

Key pattern.—B–O–M–1–2–10

Growth characteristics.—Growth medium, in seven days forming a mat 3 to 4 cm. diameter; mat dense, appressed, sometimes with thicker areas radiating from the center, white, then "light pinkish cinnamon" over central area in ten to fourteen days to "cinnamon" on inoculum; marginal zone broad, thin, appressed to submerged, margin proper inconspicuous, fimbriate; odor similar to that of green apples (1); oxidase reaction usually negative but sometimes a dark zone develops in gallic acid medium under inoculum block but does not advance with the new growth.

Hyphal characteristics.—Both submerged and young superficial hyphae staining, 1.5–4 μ diameter, some superficial hyphae becoming thick-walled and non-staining, few groups of brown-walled hyphal segments in fourteen-day-old cultures; clamps abundant; chlamydospores few, not conspicuous, long and narrow, 18–25 × 5–6 μ.

Test-tube cultures.—About the same as in Petri dishes with dense mat forming only over old inoculum, sometimes developing pores in three to four weeks.

Type of decay.—Brown carbonizing rot in Atlantic white cedar hull planking. Isolated twice.[9]

Remarks.—It is difficult to distinguish *Fomes roseus* from *F. subroseus* (Weir) Overh. but the latter is reported to be faster growing than the former (1). Since the cultures isolated from boats were slower growing than those recorded for *F. subroseus,* they are here referred to *F roseus*

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[9] One of these was isolated by C. Audrey Richards and sent to the Division of Forest Pathology, Beltsville, Maryland, for identification.

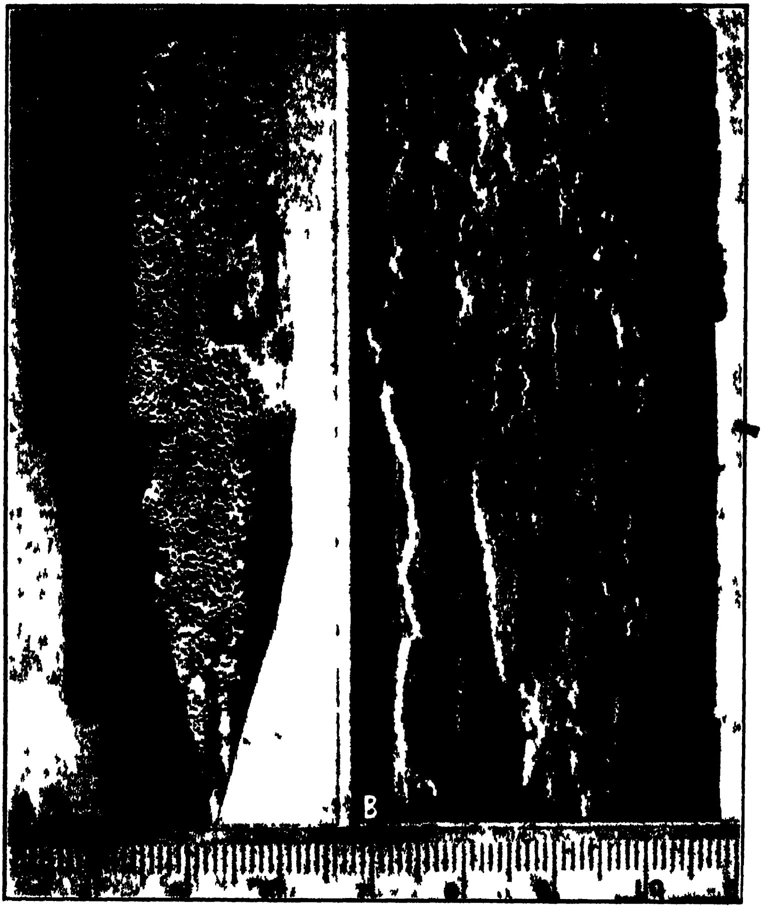

FIG 4 *A,* sporophore of *Poria microspora* fruiting on pine wood from the whaler "Charles Morgan" *B,* fruiting of *Poria xantha* on Douglas-fir from a barge

LENTINUS LEPIDEUS Fr (FIG 1, *B*, FIG 2, *C*)

Key pattern—A-O-I-1-2-10

Growth characteristics—Growth moderately rapid, forming a mat 9 cm diameter in fourteen days; mat tufted, woolly cottony, raised, peeling off from substratum easily and breaking up readily, white with buff to brownish tints at fourteen days; negative oxidase reaction.

Hyphal characteristics.—Hyphae staining with eosin, variable in size, 1.8 to 6 μ diameter, occasionally branching; clamps numerous; chlamydospores abundant, almost round, large, 10–20 × 9–13 μ, walls medium thick (about 1 μ).

Test-tube cultures.—Forming a dense, buff to brown mat over slant, with lumps or short fingerlike stalks developing in about three weeks. Fertile sporophores have never been observed in culture but the short stalks usually start to develop.

Type of decay.—Brown carbonizing decay from pine boat timbers. Isolated twice from boats. This species has been isolated from heart rot in southern pines[10] and from ponderosa pines in California (11).

Remarks.—This species is easily identified in test-tube cultures by the numerous short stalks that develop.

LENZITES SAEPIARIA Wulf. ex Fr. (FIG. 1, *C;* FIG. 2, *D*)

Key pattern.—A–O–M–1–2–4–10

Growth characteristics.—In fourteen days forming a mat 5.0 cm. diameter; mat white, thin, appressed, cottony to powdery; marginal zone irregular, sometimes thin and inconspicuous to powdery; margin proper uneven, fimbriate; negative oxidase reaction.

Hyphal characteristics.—Both submerged and superficial hyphae staining with eosin, thin, 1.8 to 3.5 μ diameter, much-branched; oidia abundant in very young cultures, cylindrical or sometimes ovoid, 4–14 × 2–3 μ, thin-walled; chlamydospores few, inconspicuous, 8–12 × 5–7 μ, thin-walled.

Test-tube cultures.—Three- to four-week-old test-tube cultures white and powdery near margins of growth but brown ("pinkish buff" to "cinnamon") on older areas of mat, coloring substratum brown near upper part of slant; mat thin powdery with cottony tufts or patches, seldom if ever raised or filling tube above slant; abortive fruiting bodies forming occasionally.

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[10] Unpublished data.

Type of decay.—Causes a brown carbonizing decay. Seven specimens collected from boats—mostly from pine deck planking containing some sapwood.

LENZITES TRABEA Fr. (FIG. 1, *D;* FIG. 2, *E*)

Key pattern.—B–O–I–1–2–4–10

Growth characteristics.—Growth moderately rapid, forming a mat 9 to 10 cm. diameter in fourteen days; mat fairly dense, floccose cottony to margin, "light buff" to "light ochraceous-buff" with darker "clay color" patches forming on some isolates, raised, about 2 mm. thick, somewhat tufted or uneven on the surface; odor sweet; negative oxidase reaction.

Hyphal characteristics.—Hyphae staining, thin-walled; submerged hyphae small, much-branched, 1.5 to 3 μ, with a few larger, up to 5 μ diameter; surface hyphae uniformly small. 2–4 μ diameter, few branches; clamps numerous on both submerged and superficial hyphae; oidia abundant in young cultures, segments of hyphae, 5–25 × 2.5–3.5 μ, hyaline, thin-walled, cylindrical, sometimes elongate-ovoid.

Test-tube cultures.—Loose to dense plug of "light ochraceous-buff" mycelium grows up into neck of tube, sometimes growing into the cotton plug.

Type of decay.—Brown carbonizing decay, usually in pine sapwood. Isolated three times from pine and Mexican mahogany.

UNIDENTIFIED FUNGUS (*producing strong odor*) (FIG. 1, *F;* FIG. 2, *F*)

Key pattern.—A–O–I–1–2–10

Growth characteristics.—Growth fairly rapid, forming a mat 7.5 cm. diameter in seven days; mat raised, loose, feathery, sometimes collapsing in central zone after six days; odor very disagreeable (putrescent) at end of fourteen days; negative oxidase reaction, good growth (4.5 cm. in 7 days) on gallic acid medium and poor growth on tannic acid but fluffing up in coarse strands and growing over the underside of Petri dish lid.

Hyphal characteristics.—Submerged and superficial hyphae staining with eosin, much-branched, small to medium sized, few large diameter hyphae with clublike ends where broken at clamps; clamps numerous and conspicuous on small and large hyphae; chlamydospores abundant, large, ovoid to almost round, 10–16 × 8–12 μ, thick-walled, intercalary or terminal, sometimes in short chains.

Test-tube cultures.—Loose feathery mat about same as in Petri dishes, dull white with no color on aging. Disagreeable odor at two to four weeks.

Type of decay.—This fungus has not been proved to cause decay in wood but it was isolated from brown rot in coniferous wood. The negative oxidase reaction also indicates that it is a brown rot fungus. It was isolated twice.

FUNGI FRUITING ON BOATS

Some of the boat decay fungi frequently develop small somewhat abortive sporophores so that, without a thorough knowledge of the species, identification is difficult. Well-developed fresh sporophores of *P. xantha* (FIG. 4, *B*) have a characteristic yellow color and cheesy texture but color and texture are not so characteristic after specimens have aged. Prominent hyphal strands are also formed by this species and are useful as an aid to identification.

Most strains of *Poria microspora* fruit readily in culture but only one identifiable sporophore was collected during the survey (FIG. 4, *A*). The sporophores are delicate and soon disintegrate when formed under natural conditions.

Lenzites saepiaria fruits readily on deck planking and was obtained as sporophore specimens more frequently than isolated from decayed wood. Most of the sporophores were from pine deck planking of barges—probably where some sapwood was present.

As mentioned previously, somewhat abortive poroid fruiting bodies were present on two of the specimens from which *Poria carbonica* was isolated. Such fruiting is difficult to identify without the aid of cultures. Table 2 lists the sporophores that were collected. Several of these fungi found fruiting but not isolated may be important decay fungi, especially *Paxillus panuoides,* which is known to cause a brown rot in buildings.

TABLE 2

FUNGI FRUITING ON DECAYED WOOD IN BOATS

Species of Fungi	Number of Times Collected	Type of Boat	Places Collected	Collectors
Poria xantha (Fr. ex Lind) Cke.	9	Barge 5, cruiser 3, schooner 1	Norfolk, Va. 3, Brewerton, N. Y. 3, Oakland, Calif. 1, Tacoma, Wash. 1, Noank, Conn. 1	Davidson 3, Hirt 3, Kimmey 1, Englerth 1, Boyce 1
Lenzites saepiaria Wulf. ex Fr.	6	Scow 1, barge 4, cruiser 1	New Orleans, La. 3, Erie, Pa. 1, Kingston, Ont. 1, Norfolk, Va. 1	Verrall 3, Hirt 2, Davidson 1
Poria carbonica Overh.	2	Scow 1, unknown 1	Seattle, Wash. 1, Kingston, Ont. 1	Englerth 1, Hirt 1
Stereum frustulosum Fr.	2	Tug 1, barge 1	Curtis Bay, Md. 1, Kingston, Ont. 1	Davidson 1, Hirt 1
Daedalea quercina L. ex Fr.	1	Barge 1	Kingston, Ont. 1	Hirt 1
Omphalia campanella (Fr.) Quél.	1	Scow 1	Kingston, Ont. 1	Hirt 1
Paxillus panuoides Fr.	1	Scow 1	Kingston, Ont. 1	Hirt 1
Polyporus versicolor Fr.	1	Barge 1	Kingston, Ont. 1	Hirt 1
Poria microspora Overh.	1	Whaler 1	Mystic, Conn. 1	Hansbrough and Spaulding 1
Peniophora sp.[1]	1	Scow 1	Kingston, Ont. 1	Hirt 1
Poria sp.[1]	4	Scow 1, barge 2, tug 1	Kingston, Ont. 2, Tacoma, Wash. 1, New Orleans, La. 1	Hirt 2, Englerth 1, Verrall 1
Schizophyllum commune Fr.	1	Cabin cruiser 1	Brewerton, N. Y. 1	Hirt 1
Stereum sp.[1]	1	Cruiser 1	Brewerton, N. Y. 1	Hirt 1
Xylaria sp.[1]	1	Barge 1	Kingston, Ont. 1	Hirt 1

[1] Fruiting bodies collected but fungi not isolated from decay; importance uncertain.

SUMMARY

Twenty species of wood rot fungi were isolated from or collected on specimens of decayed wood in boats, barges, tugs, schooners, motor boats, etc., and sporophores of several additional species known to cause decay in wood were collected. The important causes of softwood decay were *Poria microspora,* isolated 23 times; *P. xantha,* 21 times; *P. carbonica,* 7 times; and *Lenzites saepiaria,* 7 times. The more important hardwood fungi were *Poria oleracea,* obtained 12 times; *Daedalea quercina,* 9 times; and *Stereum frustulosum,* 7 times.

The more important hardwood fungi were species that also occur as heart rots in living oaks. *Poria oleracea* had previously been isolated from heart rot in oak and is described in this paper as a new species. The more important species in softwood boat timbers are known to be important in decay of buildings and other wood products, but are not known to be important causes of heart rot.

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PEZICULA MORTHIERI ON RHAMNUS[1]

J. WALTON GROVES[2]

(WITH 3 FIGURES)

The genera *Dermea* and *Pezicula* are of special interest because of the various types of conidial stages occurring in the different species. It has been shown by Groves (**1939**, **1940**, **1946**) that the form of the conidial fruiting body may vary greatly in both genera, but that in most species of *Dermea* the conidia are elongate to subfiliform whereas in *Pezicula* they are oblong-ellipsoid to ovoid. Two exceptions to this general rule have been noted, *D. acerina* (Pk.) Rehm (Groves **1938**) and *P. alnicola* Groves (Groves **1940**). It was stated by Groves (**1946**) that a third exception was known in a species occurring on *Rhamnus* and known as *Dermea micula* (Fr.) Rehm, and that a more detailed account would be published later.

The specific name used by Rehm (**1889**) was, however, based originally on the conidial stage and since the perfect stage was described earlier by Fuckel (**1870**) as *Cenangium Morthieri* the latter name must be considered valid according to the International Rules of Nomenclature.

As far as I know, the apothecia of this species have not been reported in North America, but in 1936 Mr. G. Lapointe collected it on *Rhamnus alnifolia* at St. Alphonse de Caplan, Bonaventure Co., Quebec, and I received fresh specimens in excellent condition from which I was able to obtain cultures from both ascospores and conidia.

Fuckel's original description was apparently based on the specimen distributed in Fungi Rhenani *2278*. The specimen under this number in the Farlow Herbarium, Harvard University, was examined and it agreed with the Canadian collection. In Fuckel's account, he described and figured four spored asci, but in the Canadian material and in the specimen of Fung. Rhen. *2278* that I examined, the asci were eight spored (FIG. 3). It is possible that Fuckel's material may have been a mixture of this species and *Pezicula Frangulae* (Pers.) Fckl., which has four spored asci and also occurs on *Rhamnus,* and that he may have examined a mount of the latter.

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[1] Contribution No. 890 from the Division of Botany and Plant Pathology, Science Service, Department of Agriculture, Ottawa, Canada.

[2] Plant Pathologist, Central Laboratory, Ottawa.

Fuckel noted its association with the conidial stage which he knew as *Micula Mougeotii* Duby and suggested the genetic connection, but this relationship was not established by cultural methods. The pycnidia are very striking in appearance with their long, snow-white beaks, and are much more conspicuous than the apothecia (FIG. 1). Fuckel stated that he had always thought this was the conidial stage of *Tympanis* (*Pezicula*) *Frangulae* until he saw this collection and observed it actually arising on the same "raschen." The conidial stage of *Pezicula Frangulae* has since been established by Wollenweber (1939) as *Cryptosporiopsis versiformis* (A. & S.) Wollenw.

Von Höhnel (1912) pointed out that the structure of the conidial stage had been misinterpreted by Saccardo (1879) and that he had placed it erroneously in the Stilbaceae as *Atractium Therryanum.* It was again described accurately by Dearness and House (1925) as *Sphaerographium niveum,* based on North American material, but presumably they did not have the perfect stage.

The generic position of this fungus is open to question. In color and consistency of the apothecia it is closer to *Pezicula* than to *Dermea,* but it has the narrow ascospores and asci that are more typical of *Dermea* than *Pezicula* and the conidia are definitely closer to the *Micropera* type than the *Cryptosporiopsis* type. Nannfeldt (1936) stated that it was a *Dermea.* It is one of those border-line species which could be placed in either genus with about equal justification. Because of the color and consistency of the apothecia I prefer to regard it as a somewhat aberrant *Pezicula.* The following description is based on the Canadian material.

Pezicula Morthieri (Fuckel) n. comb. (FIGS. 1–3)

Cenangium Morthieri Fuckel. Symb. Myc. p. 272. 1870.
Cenangella Morthieri Sacc. Syll. Fung. **8**: 592. 1889.

Phacangella Morthieri Sacc. & D. Sacc. Syll. Fung. **18**: 128. 1906.

Dermatea micula Rehm. Rab. Kr. Fl. I, **3**: 261. 1889. St. conid.

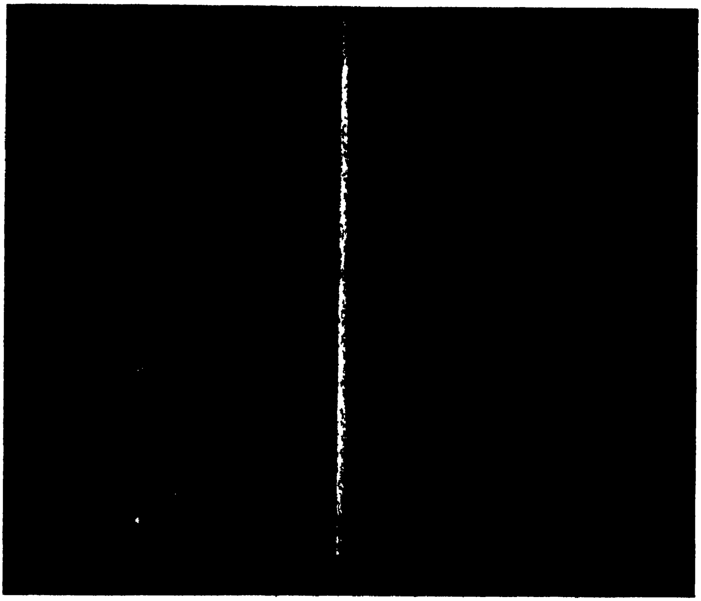

FIG. 1. Apothecia and pycnidia of *Pezicula Morthieri* from the Quebec specimen.

FIG. 2. Pycnidia produced on a twig of *Rhamnus* in culture originating from ascospores. M = 4 × approx.

Sphaeria micula Fries. Elench. Fung. **2**: 101. 1828.

Micula Mougeotii Duby. Kl. Herb. Myc. 636. 1844.

Atractium Therryanum Sacc. Mich. **1**: 535. 1879.

Sphaerographium niveum Dearn. & House. Bull. N. Y. St. Mus. **266**: 89. 1925.

Apothecia erumpent, scattered, separate or occasionally two or three in a cluster, circular or slightly irregular, sessile, narrowed below, 0.4–0.8 mm. in diameter, 0.2–0.5 mm. in height, yellowish brown to reddish brown, brittle, waxy, more fleshy when moist; hymenium at first concave, becoming plane to convex, darker than the excipulum, dark brown to almost black, becoming brighter when moist; tissue of the hypothecium compact, pseudoparenchymatous, composed of hyaline, usually slightly elongated cells 5–12 μ in diameter with the walls thickened and gelatinized, arranged in vertically parallel rows, curving obliquely toward the outside, walls of the outer cells yellowish; subhymenium indistinct; asci cylindric-clavate, short stalked, eight spored, (60)–65–95–(110) × (7.5)–8–11–(14) μ; ascospores ellipsoid-fusiform, hyaline or pale yellowish, straight or slightly curved, one to four celled, irregularly biseriate, (12)–15–20–(24) × (3.5)–4–6–(7) μ; paraphyses hyaline, filiform, septate, simple or branched, 1.5–3.5 μ in diameter, the tips not at all or very slightly swollen, and forming a slight epithecium.

Conidial fruiting bodies erumpent, scattered, separate or occasionally two or three together, sometimes arising from the same basal stroma as the apothecia, cylindric-conic, tip truncate, 200–400 μ in diameter at the base, 70–150 μ in diameter at the tip, 0.5–1.0 mm. in height, usually snow-white, sometimes darker, brittle, more fleshy when moist; tissue of the basal stroma compact, pseudoparenchymatous, composed of hyaline, almost isodiametric cells 5–10 μ in diameter with the walls somewhat gelatinized, tissue of the beak composed of two zones, an outer pseudoparenchymatous zone similar to the basal stroma, and an inner zone composed of hyaline, parallel, thick-walled hyphae 3–5 μ in diameter; conidiophores hyaline, cylindric, septate, branched, 25–40 × 2.0–2.5 μ; conidia hyaline, filiform, slightly curved to almost straight, pointed at the ends, one to four celled, (30)–45–65–(70) × (2.0)–3–4–(5.0) μ.

HOST: *Rhamnus alnifolia* L'Her.

EXSICCATI: Fuckel Fung. Rhen. *2278* (*Cenangium Morthieri* Fckl. Type); *1763* (*Micula Mougeotii* Duby); Roum. Fung. Sel. Gall. Exs. *367* (*Sphaeria Micula* Fr.); Rehm Ascom. *1411* (*Dermatea Micula* (Fr.) Rehm).

SPECIMENS EXAMINED: Herbarium of the Division of Botany and Plant Pathology, Science Service, Ottawa, Canada *19242*, on *Rhamnus alnifolia*, L'Her., St. Alphonse de Caplan, Bonaventure Co., Que. (JWG *499*).

The cultures from ascospores were similar in all respects to those obtained from the conidia and both ascospore and conidial cultures produced conidial fructifications in culture. On malt extract agar the cultures grow rather slowly, reaching a diameter of 3.5–4.0 cm. in three weeks. The colonies are circular to slightly lobed with the margin even to slightly fimbriate, whitish to pale buff, aerial mycelium short, velvety-tomentose, slightly zoned, surface flat. The conidial fructifications are fleshy, at first globose, become irregular in shape, rarely form a beak, usually tear open irregularly at the top and the spores emerge in whitish masses.

On sterilized twigs of *Rhamnus* very little aerial mycelium was produced except for a few whitish tufts around the point of inoculation. The conidial fruiting bodies (FIG. 2) were erumpent, scattered, not very abundant, at first rounded, and fleshy. They sometimes split open with the spores emerging, but sometimes develop a conical, white beak as in nature, 0.3–0.8 mm. in diameter and 0.8–1.5 mm. in height, with the conidia similar to those found in nature.

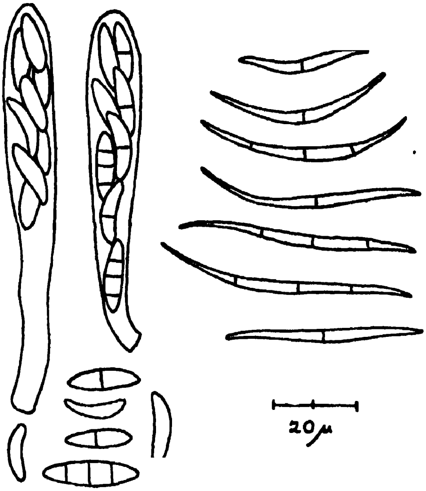

FIG. 3. *Pezicula Morthieri;* asci, ascospores and conidia.

ACKNOWLEDGMENTS

I am indebted to Mr. I. L. Conners who generously placed the Quebec collection at my disposal for cultural studies, and to the late Dr. D. H. Linder for permission to examine the type material in Fungi Rhenani.

DEPARTMENT OF AGRICULTURE,
CENTRAL EXPERIMENTAL FARM,
OTTAWA, CANADA

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BRIEF NOTES ON THE GENERA STEREOSTRATUM MAGN. AND ANTHOMYCETELLA SYD.

M. J. THIRUMALACHAR

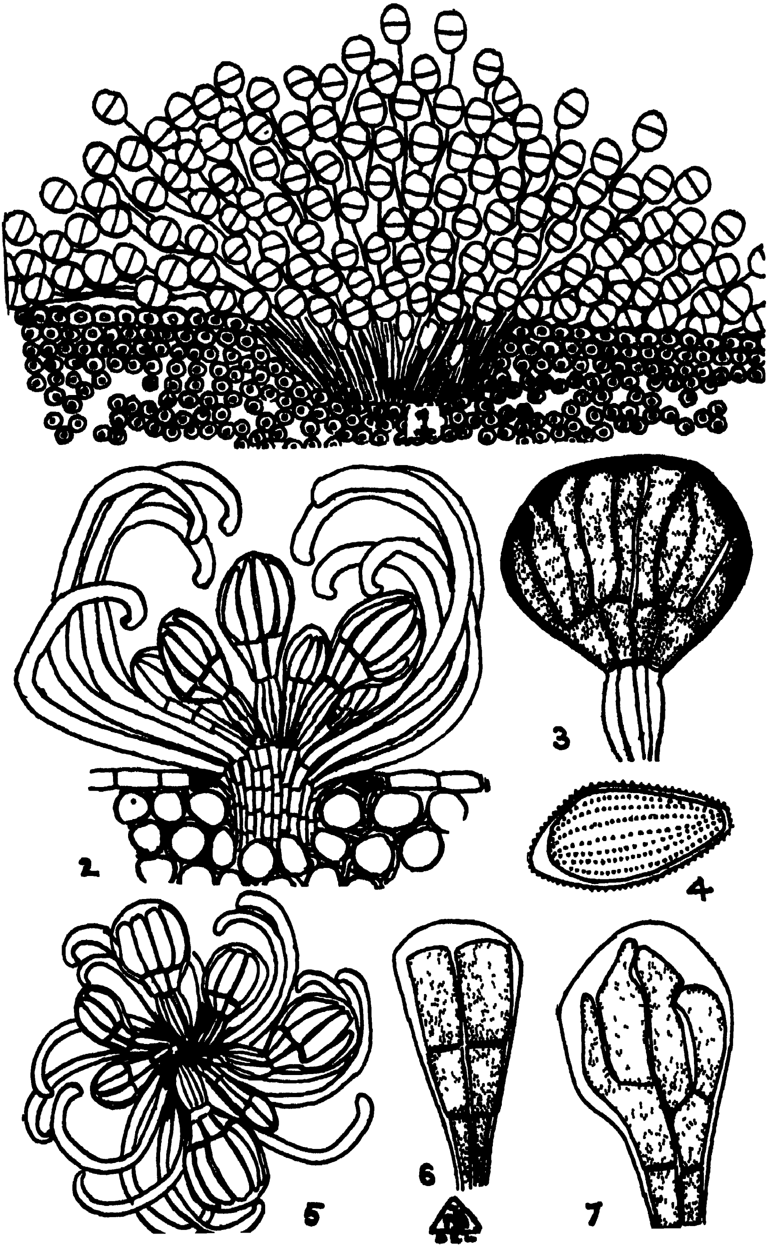
(WITH 7 FIGURES)

The bamboo rust *Stereostratum corticioides* (Berk. & Br.) Magn. belongs in a monotypic genus established by Magnus in 1899 from material collected in Japan. The rust was originally described by Berkeley and Broome (1877) as *Puccinia corticioides* and later as *Puccinia Schottmullerii* by Hennings (1893). The presence of two-celled hyaline teliospores grouped in sori which form large *Corticium*-like crusts measuring sometimes up to 10 cm. in diam. and each spore with three germ pores in each cell were considered by Magnus as diagnostic characters for the genus *Stereostratum.* The genus has been recognized by Dietel (1928) and others though the Sydows (1904) in the Monographia Uredinearum, I, treated it as a synonym of *Puccinia* by retaining the name *Puccinia corticioides* Berk. & Br. However, in Sydow's *Fungi Exotici Exsiccati* No. 953, collected in Kyoto, Japan, in 1933 by Kiyoshi Aoki, the rust has been distributed under the name *Stereostratum corticioides.* A small fragment of this specimen bearing the number 953 was made available for study through the kindness of Dr. Th. Arwidsson of the Natural History Museum, Stockholm. Although the type of the genus is recorded on *Bambusa metake* (= *Arundinaria japonica*), the collection made by Kiyoshi Aoki and distributed in Sydow's Fungi Exotici Exsiccati No. 953 is on *Phyllostachys bambusoides.*

Only uredia and telia are known for the genus. The uredia form striate sori developing urediospores. The telia which are present on the woody culms are of extreme interest because they form sori which are described as being *Corticium*-like and measure up to 10 cm. in diameter. Such large sized sori are very peculiar and so far unknown among other rust genera. In the material at the disposal of the writer the telia had formed crusts measuring from 5 to 8 mm. in diam. and a study of the structure of the sorus and the development of the teliospores was made.

Sectioning of the material is rendered very difficult because of the sclerotic nature of the woody culms. However, thin sections were secured after softening the material. Observations indicate that the sorus is subepidermal, and formed by the displacement of the sclerotic cells of the host by hyphal strands. In transverse sections, the sorus appears as a concave depression lined with hyphal strands. From the base of the hymenium, a large number of pedicellate teliospores, which are two-celled and hyaline, are produced in succession. The teliospores so developed are not persistent but soon become separated from the sorus and are pushed upwards by the developing younger spores from the base. The younger teliospores are developed between two older ones and appear wedged in between them. The teliospores are therefore formed in succession from the base in the same manner as in the tribe Pucciniosirae of Dietel (1928) and in particular as in the genus *Kernia* recently described by the writer (1946). In *Kernia*, however, the teliospores are grouped compactly to form long, semipermanent *Cronartium*-like spore tendrils. In *Stereostratum* on the other hand, the older teliospores are pushed laterally without any compact arrangement (FIG. 1) and the long pedicels, which are up to 350 μ long, intertwine with one another, with the result that a spreading pulvinate cushion-like sorus is produced. As more spores are added from the base the upper spores are pushed farther off with the result that the diameter of the sorus increases. It has also been noticed that along the border of the sorus more and more basal cells are differentiated abstricting more spores, thereby widening the breadth of the basal hymenium. The development of such large sori is made possible by the method of spore formation mentioned above.

Mature teliospores are thin-walled, hyaline, two-celled, slightly or not at all constricted at the septa, not thickened at the apex, and measure 24–34 × 18–25 μ. The epispore is smooth to ruffled, and shows three distinct germ pores. The pedicels are hyaline, intertwining with one another, persistent, up to 350 μ long, and taper into thin hyphoid strands for the most part at the base.



FIGS. 1–7. *Stercostratum* and *Anthomycetella*.

The genus *Stereostratum* is placed in the Uropyxideae by Dietel (1928) who placed it in that tribe with some reserve, and considered it doubtful as to whether the mere presence of three germ pores would warrant its inclusion in that tribe. The other genera included under Uropyxideae all possess three distinct wall layers in addition to the number of germ pores, a character not duplicated in *Stereostratum*. The presence of more than one germ pore is known in a number of other genera not included under Uropyxideae and taking into consideration the development of teliospores in succession from the base of the hymenium it seems reasonable to place the genus *Stereostratum* in the tribe Pucciniosirae.

The genus *Anthomycetella* Sydow (1916) was established to accommodate a leaf rust on *Canarium villosum* from the Philippines, and was later described by Saccardo (1917) under the name *Reyesiella* Sacc. The rust is characterized by the possession of telia having multicellular telial heads borne on compound pedicels composed of three to four hyphal strands. The teliospores are stated to be arranged in two tiers, the upper one having always a larger number of spores than the lower tier. The sori are covered by incurved cylindric paraphyses, which according to Sydow are coalescent at the base. The genus *Anthomycetella* is described as being closely related to *Anthomyces* Diet. but differing from it in the possession of a compound pedicel and lack of cysts, which, however, are characteristic of the latter genus. In the arrangement of the superposed teliospores, Sydow finds some relationship between the genus *Anthomycetella* and *Pleoravenelia*, but in the structure of the telial head the two show considerable difference.

A small fragment of an authentic specimen of *Anthomycetella Canarii* Syd., which is the only species known for the genus, was made available through the kindness of Dr. Th. Arwidsson. The material was collected in the type locality Los Baños, Philippines, by Baker, the identification being made by Sydow. A brief study of the material revealed certain interesting features not recorded in the descriptions, and it is considered worthwhile to place them on record.

Sections through the leaf indicated that prior to the formation of the telium, which is the only spore form so far known for the genus, strands of hyphae become grouped beneath the stoma and emerge by pushing apart the guard cells. The strands of hyphae bear the telial sorus above the epidermis with the pedicellate telial heads arising in the middle and the strongly incurved cylindric paraphyses developing along the margin (FIG. 2). The paraphyses possess a few septations here and there and completely envelope the telia. In the method of telial development there is very close resemblance with that of the uredia of *Crossopsora Zizyphi* Syd. recently described by Mundkur and Thirumalachar (1946). When the sorus is scraped with a scalpel to get some spore mounts, the entire sorus gets detached by the abscission of the hyphal strands above the stoma. Consequently the paraphyses which are marginal and are attached to the hyphal strands appear to have coalesced at the base (FIG. 5).

The developmental stages of the telial heads have been followed as far as the scanty material at the disposal of the writer permitted. In the early stages of development, the sorus is composed of two to three layers of hyphal strands composing the pedicel and the same number of hyphal cells above them. From each of these hyphal cells, which by now become enclosed within a membrane, a teliospore is formed above, which elongates and becomes cylindric (FIG. 6). The same basal hyphal cell continues to abstrict off more teliospores laterally with the result that an umbellate cluster of teliospores is produced of which the centrally situated ones are the oldest and the marginal ones are youngest (FIGS. 3 and 7). Various stages in the formation of teliospores from the basal cell, which should more properly be considered a sporogenous basal cell, have been followed. All the spores thus produced are enclosed within a brownish-yellow wall which appears to become slightly gelatinous in later stages (FIG. 3). Consequently in a mature telial head we can observe the compound pedicel composed of three to four hyphal strands, three or four basal cells bearing 18 to 24 clavate to rectangular teliospores. These basal cells have been treated as teliospores by Sydow (1916), Dietel (1928) and others and consequently the telial heads are described as having two superposed tiers of spores on a compound pedicel. The method of spore formation from each basal cell as well as a few cases of germination observed in some of the teliospores indicate beyond a doubt that the lower tier of cells are not of the nature of spores. In some of the mature telial heads that were noticed, the apex of the teliospores had prolonged into a four-celled promycelium. The germ tube breaks through the gelatinous envelope and the contents of the teliospore migrate into the promycelium thus formed. None of the lower tiers of cells had developed any such germ tubes, indicating that they are only of the nature of basal cells and not spores. In the figure of *Anthomycetella Canarii* given by Dietel (1928), two tiers of teliospores superposed over one another without any common membrane enclosing the telial heads are shown. A careful examination of the teliospores in the authentic specimen of *Anthomycetella Canarii* indicates that the illustration is not appropriate.

A few urediospores were seen intermixed with young telia, and separate uredia have not been observed in the material at the disposal of the writer. The uredia are so far unknown for the genus, only the telial stages having been described. The urediospores (FIG. 4) are ovate ellipsoid, thin-walled, hyaline in the exsiccati material, densely echinulate and without any distinct germ pores. The spores measure 32–35 × 16–20 µ. The echinulations on the spore are arranged in definite vertical rows giving a striate appearance.

The genus *Anthomycetella* is placed in the tribe *Raveneliae* by Dietel on account of the formation of telial heads and the presence of compound pedicels. There is only umbellate cluster of spores produced from the basal sporogenous cells which are up to three to four in number and not two superposed tiers of spores as originally described. It we could imagine clusters of teliospores of a *Chaconia* like *C. Butleri* (Syd.) Mains as being enclosed within a common spore membrane to form a head, the whole telial head being borne on strands of hyphae, we arrive at the condition in the telial head of *Anthomycetella.*

In conclusion the writer wishes to acknowledge his grateful thanks to Dr. Th. Arwidsson of the Cryptogamic Herbarium, Naturhistorika Riksmuseet, Stockholm, Sweden, for sending the valuable specimens used in the present study.

UNIVERSITY OF WISCONSIN,
MADISON, WISCONSIN.

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DESCRIPTION OF FIGURES

FIG. 1. Section through the telium of *Stereostratum corticioides* × 150. FIG. 2. Section through the telium of *Anthomycetella Canarii* × 200. FIG. 3. Mature telial head × 400. FIG. 4. Urediospore × 1000. FIG. 5. Surface view of the entire sorus from the scraped material × 200. FIGS. 6 and 7. Development of teliospores from the basal cells × 800.

SELENOPHOMA LINICOLA SP. NOV. ON FLAX IN SASKATCHEWAN[1]

T. C. VANTERPOOL[2]

(WITH 10 FIGURES)

At harvest time in 1944 a fungus with mature pycnidia and belonging to the genus *Selenophoma* Maire (5 and 7) was collected on the fine branches and pedicels (FIG. 1) of linseed flax (*Linum usitatissimum* L.) in the experimental plots at the University. The pycnidia were separate, but inclined to be arranged in longitudinal lines, in zones 3–20 mm. in length and usually encircling the stem. This fungus appears not to have been previously reported on flax. A week later it was detected on a sample of flax from a field at Elstow, Saskatchewan. Pure cultures were readily obtained, both by culturing surface-sterilized portions of infected stems, and by spore dilutions on ordinary laboratory media. Pycnidial production was best on malt-extract agar. The fungus was again collected on April 23, 1945, in a viable condition on overwintered flax straw (FIG. 2) in the experimental plots. It was fairly common on mature plants of several varieties in the late summer.

DISTRIBUTION. Pre-harvest surveys in 1946 revealed that there were light infestations of the *Selenophoma* species generally distributed on flax, specimens being found at White Fox near the limit of the flax-growing area in the north of the province and extending to the Estevan district near the southern boundary. The infested area extended from the South Saskatchewan River in central Saskatchewan eastward to near the Manitoba boundary. Relatively fewer specimens were collected in the north, possibly because of the delayed maturity of the crops. The distribution of the fungus in the western part of the province has not been determined. The wide distribution of the species of *Selenophoma* on flax as revealed by the 1946 survey suggests that the fungus was generally present before its discovery in 1944. However, an examination of a limited amount of herbarium specimens and class material collected from 1940 to 1943, and one 1923 collection, has failed to show the presence of the fungus.

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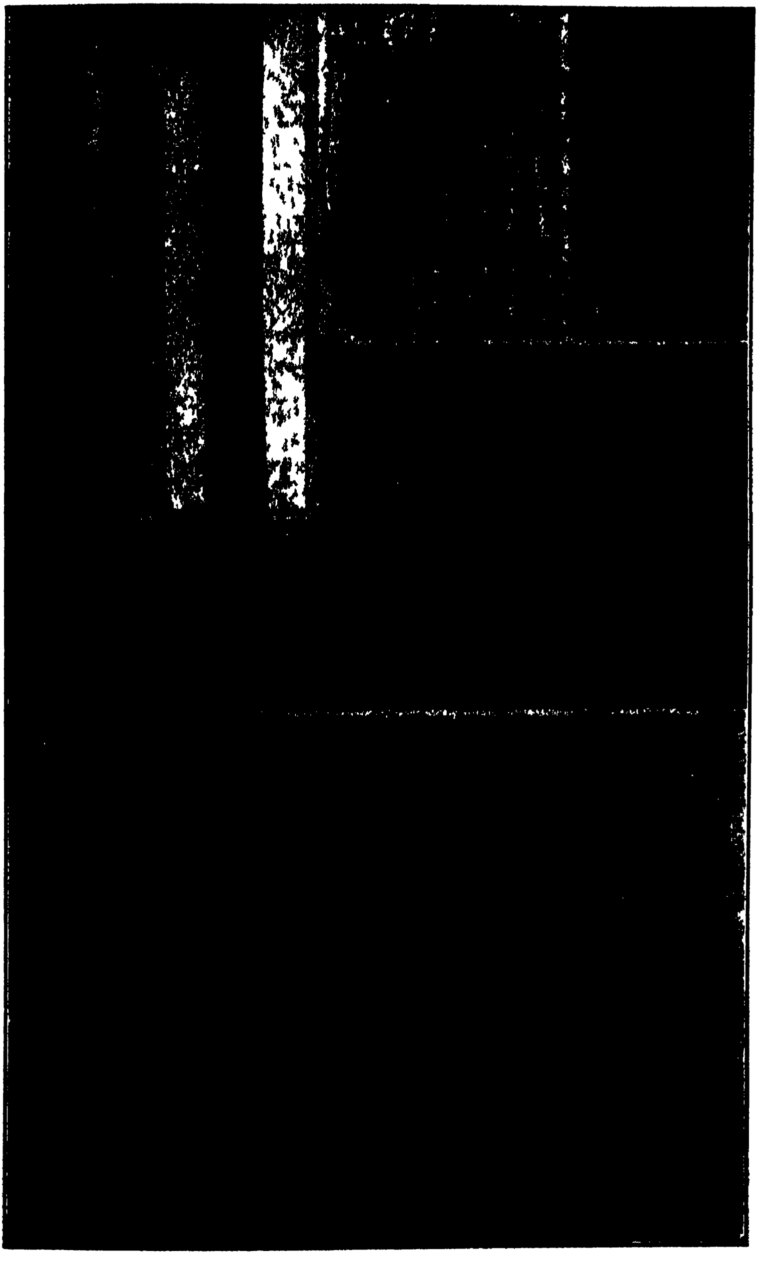
[1] Contribution from the Laboratory of Plant Pathology, University of Saskatchewan, Saskatoon, with financial assistance from the Saskatchewan Agricultural Research Foundation.

[2] Professor of Plant Pathology.

HOST RELATIONSHIPS. In artificial inoculation of flax seed with spore suspensions or agar discs of inoculum on moist filter paper in Petri dishes there is a slight inhibition of growth in length of the roots, accompanied by curling and an increase in branch roots. No infection occurred when green flax plants in the early stages of boll development were sprayed with a spore suspension and kept in a moist chamber in the greenhouse for several days. In the field, the pycnidia are found most commonly on early maturing varieties such as Redwing; on plants affected with die-back (9), a physiological trouble in which the upper third of the plant dries up prematurely; and on plants prematurely killed from other causes, such as late root rot (a disease complex) and scorching caused by drought and hot dry winds late in the season. Occasionally, pycnidia are found on pedicels the bolls of which have failed to develop. It seems more probable that the *Selenophoma* has developed mainly as a saprophyte and that the flowers or young bolls have been blighted from some other cause; however, the possibility that under optimum conditions the fungus may show definite parasitic ability should not be ruled out. Comparison might be made with certain serious flax pathogens such as *Sphaerella linorum* Wr. (pasmo) and *Polyspora lini* Laff. (browning and stem-break) which frequently do not develop until quite late in the season under the semi-arid prairie environment. Seed yield in the linseed varieties is not appreciably affected under such circumstances. At present *Selenophoma* is of no economic importance on flax. It has been found on the following linseed varieties: Arrow, Bison, Bolley's Golden, Buda, Crystal, Custer, Dakota, Malabrigo, Redson, Redwing, Rocket, Royal, Sheyenne and Victory; and on the fibre variety Stormont Cirrus. It has not been detected on wild flax (*Linum Lewisii* Pursh).



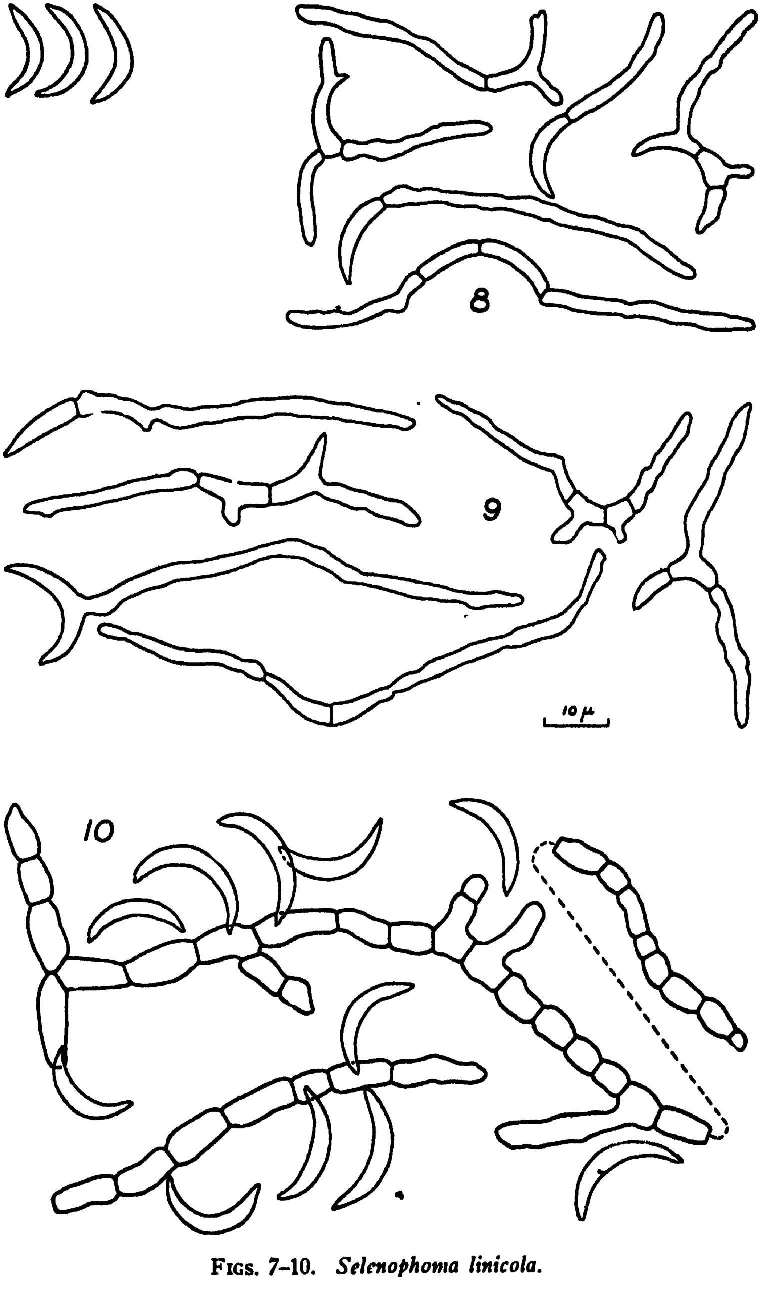
FIGS 1–6 *Selenophoma linicola*

During the last five years several hundred flax-seed samples have been examined for seed-borne fungi by the plating method, and no colony of *Selenophoma* has been detected. Its extremely slow growth, if it were present, and the blanketing action of the high percentage of *Alternaria* species, mostly saprophytic and commonly associated with flax seed, may possibly account for this.

It is not known how the fungus persists during the summer. As stated below, the flax form resembles *S. bromigena* (Sacc.) Sprague and Johnson (3 [*Septoria bromigena* Sacc.] and 8) more closely than any of the other species of *Selenophoma* found on the prairies (6 and 8). According to Allison (2), infections of *S. bromigena* on *Bromus inermis* Leyss. arise early in the season; this suggests that a careful search might possibly reveal *Selenophoma* leaf lesions on flax.

MORPHOLOGY AND TAXONOMY. Specimens of the fungus on flax were sent to Dr. Roderick Sprague, who confirmed the *Selenophoma* diagnosis and further suggested that it should be described as a new species.

In comparison with species of *Selenophoma* reported from the Northern Prairies (3, 6, and 8), spore measurements of the flax form (17–22 × 2.7–3 μ) were found to be intermediate between those of *S. bromigena* (21–27 × 2.8–3.5 μ), and *S. donacis* (Pass.) Sprague & Johnson var. *stomaticola* (Bauml.) Sprague & Johnson (13–23 × 1.5–3 μ). In general cultural characteristics, in proneness to sectoring and in spore size and shape, the flax form is more nearly like *S. bromigena* than *S. donacis* var. *stomaticola*, though the spore measurements of the flax form from both cultural and natural material are consistently smaller than those of *S. bromigena*. Since *S. bromigena* is apparently confined to species of *Bromus* (2 and 8), cross-inoculation studies on flax and grass hosts should provide some supporting evidence on specific identity. In preliminary cross-inoculations in the greenhouse and in the field no infection was obtained on *Agropyron cristatum* (L.) Gaertn., *Agropyron pauciflorum* (Schwein.) Hitchc., *Bromus inermis*, and *Stipa comata* Trin. & Rupr., when these were inoculated with the flax form, neither did flax become infected when inoculated with *S. bromigena*.



FIGS. 7–10. *Selenophoma linicola.*

Allison (2) found spores of *S. bromigena* to be multinucleate, but those of the flax form may be either uninucleate or multinucleate. They are also usually vacuolate (FIG. 5). The terminal type of germination in water or on plain agar and the septation type on nutrient media as reported by Darley (4) for *S. bromigena* have not been found to be as clear-cut in the flax form (FIGS. 8 and 9).

The phenomenon of spore formation was observed on the mycelium on eight-day old cultures on plain and potato-dextrose agar plates prior to the formation of pycnidia (FIGS. 6 and 10). Spores were usually more numerous than those shown in these illustrations, and on the potato-dextrose agar plate the mycelium was dark and the septations closer, the individual cells being thicker-walled and chlamydospore-like. Pycnidial initials were beginning to form. *S. bromigena* behaved similarly but, in addition, occasional large, usually septate allantoid spores were observed.

On the basis of differences in spore size and host range, the flax *Selenophoma* is considered as a hitherto undescribed species and has been assigned the binomial *Selenophoma linicola.*

Selenophoma linicola sp. nov. Pycnidia dispersa, saepe in rectis lineis, in maculis 3–20 mm. longis et plerumque circum caulem complexis, subepidermalia, depresse globosa, globosa vel oblonga, desuper intuentibus, brunnea vel atra, nonnihil glabra, media 131 × 92 μ, plerumque 110–140 × 85–110 μ; pycnosporae unicellulares, hyalinae, vacuolatae, lunatae vel falcatae, plerumque 17–22 × 2.7–3.0 μ, minimae 13 × 2 μ, maximae 26 × 3.2 μ.

Hab. In aridis, tenuibus ramis pediculisque *Lini usitatissimi* in mediis orientalibusque partibus Saskatchewan, Canada.

Type: Saskatoon, August, 1946, on the Royal variety.

The flax *Selenophoma* is easily cultured on the common laboratory media. The colonies are generally flat, non-lustrous, of mixed shades of dull white, gray and buff, grading through olivaceous to black, broadly concentric, with dull-white margins. Mycelial growth is slightly aerial at the center and the surface frequently develops into irregular folds. Both monosporous and multisporous cultures of most strains are given to the production of pale buff, sterile, sectors or variants (*cf.* 1). Radial growth on potato-dextrose and malt-extract agar is about 1 mm. in 24 hours at 22° C. Pycnidia form after about 14 days.

The pycnidia (FIGS. 1, 2, 3, and 4) are scattered, but frequently in longitudinal lines, in zones 3–20 mm. long and usually encircling the fine branches and pedicels of flax, dark brown to black, subepidermal but raised, flattened-globose with a slight central depression, subspherical to oblong in surface view, have thick dark peridial walls, average 131 × 92 µ (the majority falling within a range of 110–140 × 85–110 µ). The ostiole measures about 11 × 23 µ and expands up to twice these dimensions on swelling in water after spore discharge (FIG. 4).

The pycnospores (FIGS. 5 and 7) are unicellular, hyaline, lunate to falcate, uninucleate or multinucleate, usually vacuolate, typically 17–22 × 2.7–3 µ from natural material, with a range of 13–26 × 2–3.2 µ; those produced in culture are larger; germination is usually preceded by septation, especially on nutrient media.

The fungus is found on dried fine branches and pedicels of linseed flax (*Linum usitatissimum* L.) at harvest time, and is distributed over the eastern half of the province of Saskatchewan. Type specimens have been placed in the Mycological Herbaria of the University of Saskatchewan, Saskatoon, and of the Division of Botany and Plant Pathology, Central Experimental Farm, Ottawa.

SUMMARY. A new fungus belonging to the genus *Selenophoma* is reported on dead branches and pedicels of flax in central and eastern Saskatchewan. It is the first report of a *Selenophoma* on *Linum* and is described under the binomial *S. linicola.* The fungus overwinters on flax stubble, but there is no evidence that it is seed-borne. Cross-inoculations of the flax form on certain grasses and of *S. bromigena* (Sacc.) Sprague & Johnson on flax were negative. Flax is the only known host.

ACKNOWLEDGMENTS. My thanks are due to Dr. Roderick Sprague, formerly of the Northern Great Plains Field Station, Mandan, North Dakota, for his willing help in determining the identity of the species and for supplying mycological specimens for comparative studies; and to Professor R. M. Ferguson, University of Saskatchewan, for his kindness in writing the Latin diagnosis.

DEPARTMENT OF BIOLOGY,
UNIVERSITY OF SASKATCHEWAN,
SASKATOON, CANADA

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DESCRIPTION OF FIGURES

FIG. 1. Pycnidia of *Selenophoma linicola* on a fine branch of a mature flax plant, × 8. FIG. 2. Over-wintered pycnidia, × 8. FIG. 3. Pycnidia freshly mounted, × 150. FIG. 4. Pycnidium, after discharging spores, × 200. FIG. 5. Spores stained with lacto-phenol-nigrosin, × 900. FIG. 6. An eight-day culture on plain agar, showing spores produced on mycelium before pycnidia formed, × 150.

FIG. 7. Spores of *Selenophoma linicola.* FIG. 8. Spores germinating on plain agar after fifteen hours. FIG. 9. Spores germinating on potato-dextrose agar after fifteen hours. FIG. 10. Spores produced directly on the mycelium on an eight-day plain-agar culture before pycnidia formed, × 800.

AN UNDESCRIBED SPECIES OF SPOROTRICHUM ON AGROPYRON[1]

RODERICK SPRAGUE[2]

(WITH 1 FIGURE)

A newly recognized parasitic species of *Sporotrichum* is widespread in the Columbia Basin of Washington and Idaho on *Agropyron spicatum* (Pursh) Scribn. & Smith, and on *A. inerme* (Scribn. & Smith) Rydb. George W. Fischer, who collected all of the material seen by the writer, found the fungus as far east as the vicinity of Bozeman, Montana, on *A. spicatum* and on *A. subsecundum* (Lk.) Hitchc. near the Yellowstone National Park at Trude, Idaho. The designated type on *A. spicatum* was collected at Roosevelt, Washington, on the Columbia River.

The lesions on the leaves are obscure, straw-colored or eventually tawny. They are scarcely distinguishable from drought-killed leaves. The infected leaves tend to become curved or recurved and show small wrinkles or blisters in the infected parts. The stromata are readily visible under the hand lens as vein-delimited, serried, nearly white stippling which resembles machine-stitching. These stromata are firm and not cottony as in *S. peribebuyense* Speg. and are 40–150 × 15–24 μ in diameter. The hyaline mycelium is compacted, sometimes crushed, but when distinguishable the hyphae are 2–5 μ in diameter, branched and septate. It is somewhat finer than that of *S. peribebuyense* on *Setaria lutescens* (Weigel) F. T. Hubb from Boynton, Oklahoma.

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[1] Coöperative investigations between the Divisions of Cereal Crops and Diseases, Forage Crops and Diseases, Soils, Fertilizers, and Irrigation, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration; Nursery Division, Soil Conservation Service, U. S. Dept. of Agriculture; and the North Dakota and Washington Agricultural Experiment Stations.

[2] Formerly Pathologist, Division of Cereal Crops and Diseases, and Collaborator, Division of Forage Crops and Diseases, Northern Great Plains Field Station, Mandan, North Dakota.

There are microspores, 2–4.5 × 0.8–1.5 µ, and macrospores, 3–8 × 2.5–6 µ, mingled with the hyphae. The macrospores produce secondary conidia by budding and because of their yeast-like appearance together with the fact that no viable material has been available for isolation in pure culture, there remains some doubt as to whether the macrospores are part of the life cycle (FIG. 1, *A*). The spores of *S. peribebuyense* in the Oklahoma material, it should be added, are larger, globose, hyaline, 8–11.2 µ (FIG. 1, *B*), but somewhat smaller in the type. The western species is therefore distinct from the only comparable species. It in no way resembles *Fusarium Poae* (Pk.) Wr., which for some years was placed in the genus *Sporotrichum*. The new fungus shows little relation to the well known parasite of man, *S. Schenckii* (Hektoen and Perkins) Matruchet. On the basis of available information the undescribed fungus is placed in the genus *Sporotrichum* and described as new as follows:

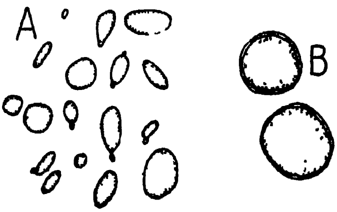

FIG. 1: *A*, spore forms associated with stroma of *Sporotrichum columbiense* on *Agropyron inerme*, Newman Lake, Wash., B.P.I. *81,171*. *B*, conidia of *Sporotrichum peribebuyense* Speg. on *Setaria lutescens*, Boynton, Okla., J. H. McLaughlin and W. W. Ray coll. Both × 1000.

Sporotrichum columbiense sp. nov. Maculis diffusis, stramineis v. fulvellis; stromatibus firmis, albidis, linearibus, in lineis dipositis, 40–150 × 15–24 µ; myceliis minutis v. 5 µ diam., compactis, prostratis; conidiophoris ramosis, prostratis, 3–5 µ diam.; conidiis variabilibus, subglobosis v. subcylindraceis, microsporis 2–4.5 × 0.8–1.5 µ; ? macrosporis 3–8 × 2.5–6 µ.

Hab. in foliis vivis *Agropyri inermis* prope Newman Lake, Wash., June 23, 1945, B.P.I. *81,171;* ibid., Washtucna, Wash., June 18, 1943, B.P.I. *81,174; Agropyri spicati*, prope Roosevelt, Wash., June 23, 1943, B.P.I. *80,934* (**typus**); ibid., Belgrade, Mont., July 30, 1945, B.P.I. *81,172;* ibid., Whitehall, Mont., Aug. 2, 1945, B.P.I. *81,173;* ibid., Livingston, Mont., July 31, 1945, B.P.I. *81,175;* ibid., 30 miles n. of Bozeman, Mont., July 31, 1945, B.P.I. *81,176* et *81,177; Agropyri subsecundi*, Trude, Idaho, July 28, 1945, B.P.I. *81,178*. Leg. George W. Fischer.

WASHINGTON STATE COLLEGE,
PULLMAN, WASH.

SPECIES OF SYNCHYTRIUM IN LOUISIANA. IV. TWO NEW SPECIES OF SYNCHYTRIUM

MELVILLE T. COOK

(WITH 4 FIGURES)

Synchytrium oxalidis sp. nov.

Gallis singulis, quarum paucae sunt in foliis petiolisque sitae, 160 μ diametro, colore a flavo in aurantiacum variantibus. Gallis compositis in basibus petiolorum, magnis et soros multos continentibus. Soris flavis, aurantiacis, subrubris, circa 22–26 μ diametro. Sporangiis paucis, circa 6–8 μ diametro. Hab. *Oxalys repens* Thunb., Baton Rouge, La., U. S. A.

Compound galls on bases of stems and petioles of the host plants cause pronounced swellings, usually on one side (FIG. 1 *A*), and contain many infected cells. Small galls are few, more or less spherical, usually containing a single infected cell, and occur on petioles and leaves, and are about 160 μ in diameter. The infections occur in epidermal cells (FIG. 1 *B* to *D*) but are most abundant at the bases of the petioles, which become swollen due to the stimulation of cell division and growth (FIG. 1 *A*, *E*), green, becoming light green to light yellow. The infected cells are more or less spherical and enlarge rapidly. The sori are solitary, grow rapidly and fill the infected cells except for the small amount of host cell material which may persist until the formation of the sporangia and occasionally become hard (FIG. 2 *A* to *D*). Compound galls at bases of petioles are formed by overgrowths due to successive infection of newly formed cells. The host cells surrounding the infected cells divide and grow rapidly and many of them become infected. The stimulus extends much farther from the infected cells than in any other species studied by the writer, and results in the formation of compound galls. The infected cells are submerged (FIG. 1 *E* to *G*), due to the excessive growth of surrounding tissue. Infections of these newly formed cells are so numerous that the compound galls contain a large number of in-

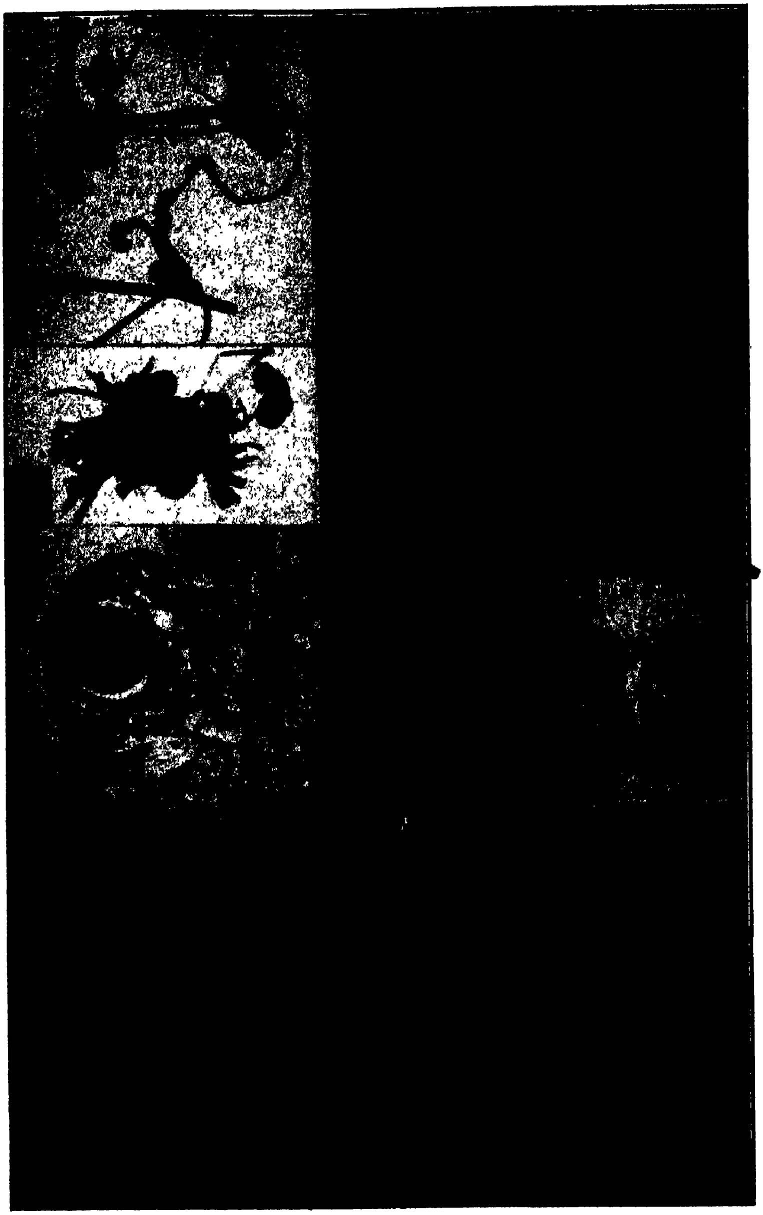

FIG. 1. *Synchytrium oxalidis.*

fected cells; the older and larger of these are submerged to a greater depth than the younger infections (FIG. 1 *E, F*). In some cases the newly infected cells may grow more rapidly than the older ones (FIG. 1 *G*). In order to get a correct idea of the relationship of old and newly infected cells to the host tissues, the section must be cut across the petiole and at right angles to the surface of the swollen region.

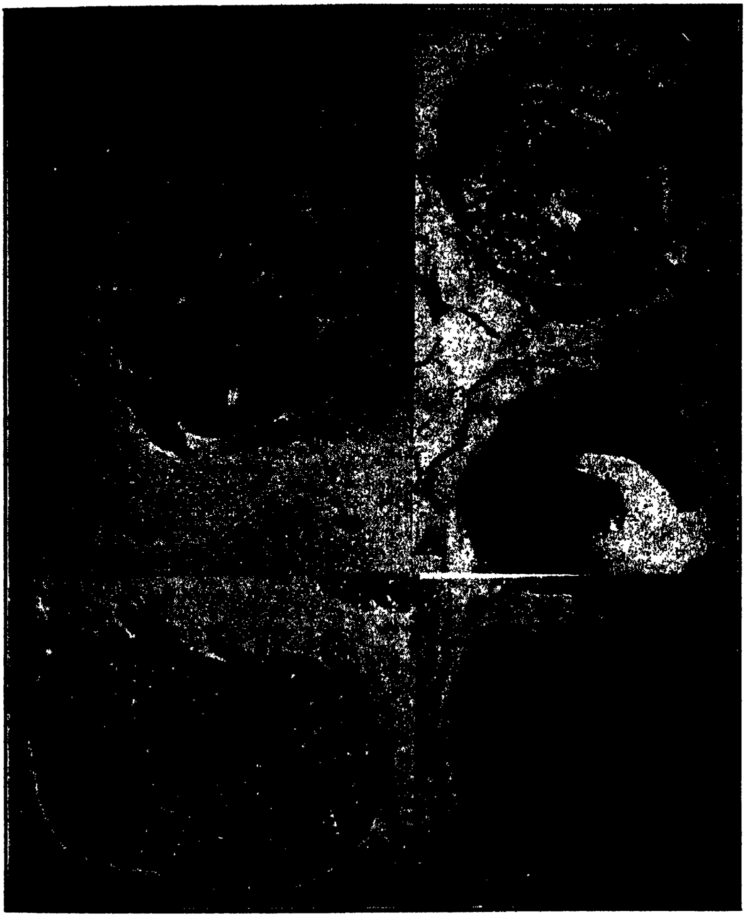

FIG. 2. *Synchytrium oxalidis.*

The sori are light green, becoming lemon yellow, orange, and finally dark red with age, and are about 22–26 μ in diameter at time of maturity. They grow rapidly, are usually surrounded by a thick mass of host cell material which becomes granular, stains very deep and becomes hard in some cases (FIG. 1 *D*, *E*, 2 *A*). The host cell material usually decreases to form a very small zone as the time for formation of sporangia approaches (FIG. 2 *B* to *D*). The host cell nucleus can be seen in young infections but disappears early (FIG. 1 *C*). The nucleus of the sorus is prominent. The wall around the sorus can be seen very early, is prominent, and very thick in some cases but becomes thin with age (FIG. 1 *B* to *G* and FIG. 2 *A* to *D*). The sporangia are formed by walls uniformly throughout the sorus (FIG. 2 *B* to *D*). This is very similar to *S. decipiens* (Peck) Farlow. They are more or less spherical and about 6–8 μ in diameter. The host tissues degenerate early.

Synchytrium ranunculi sp. nov.

Gallis singulis, in foliis petiolisque numerosis, subflavis, subrubris nigrisque, 60 μ diametro. Soris colore a lurido in fulvum variantibus, 12 μ diametro. Sporangiis 6–8 μ diametro.

Hab. *Ranunculus pusillus* Poir., Baton Rouge, La., U. S. A.

Galls single and numerous on upper surfaces of leaves and on petioles (FIG. 3 *A*), yellowish at first, become reddish and finally black, about 60 μ in diameter. The infections are in the epidermal cells (FIG. 3 *B*) which become more or less spherical, gradually enlarge and are covered with a single layer of epidermal cells (FIG. 3 *C* to *F*). The opening to the infected epidermal cell is very definite (FIG. 3 *F*). In a few cases, two sori were observed in the same cell (FIG. 4 *A*).

The sorus enlarges very early so as to completely fill the infected cell except for a thick layer of material which is formed from the host cell contents (FIG. 3 *B* to *F*). In some cases the host cell material is thick and hard (FIG. 3 *F*). The sorus is about 12 μ in diameter and is surrounded by a very definite cell wall (FIG. 3 *B* to *F*). The nucleus of the sorus is prominent. The fate of the nucleus of the host cell was not determined but it probably disintegrates very soon after infection. The walls of the sporangia are formed throughout the sorus as in *S. decipiens* and *S. oxalidis* (FIG. 4 *B*). The sporangia are about 8 μ in diameter and the number is much smaller than in the other *Synchytrium* reported

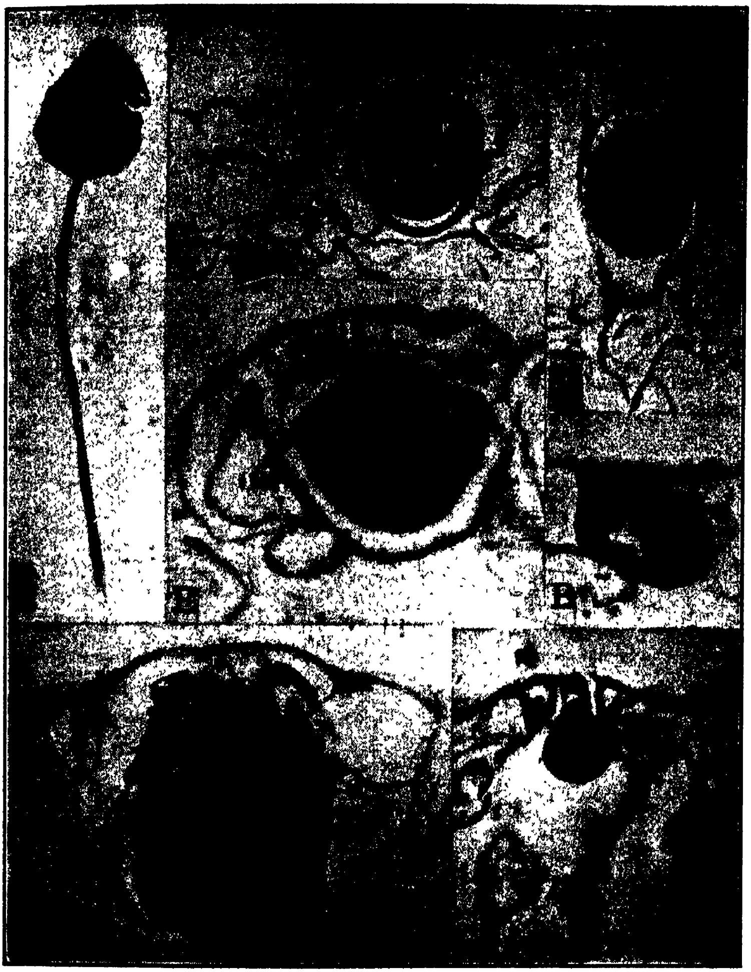

FIG. 3. *Synchytrium ranunculi.*

here by the author. They separate early and become more or less spherical (FIG. 4 *D*). In a few cases, two sori were observed in a single host cell (FIG. 4 *A*), but in all cases observed, only one developed.

A very unusual phenomenon was observed in this species. In some cases the sorus was observed in the substomatal cavity (FIG. 3 *G*). Apparently entrance was made through the stomata. In these cases the sorus was small, pear-shaped and contained a single nucleus The fate of these sori was not determined, but in all probability they perished for want of food since they were not in a cell.

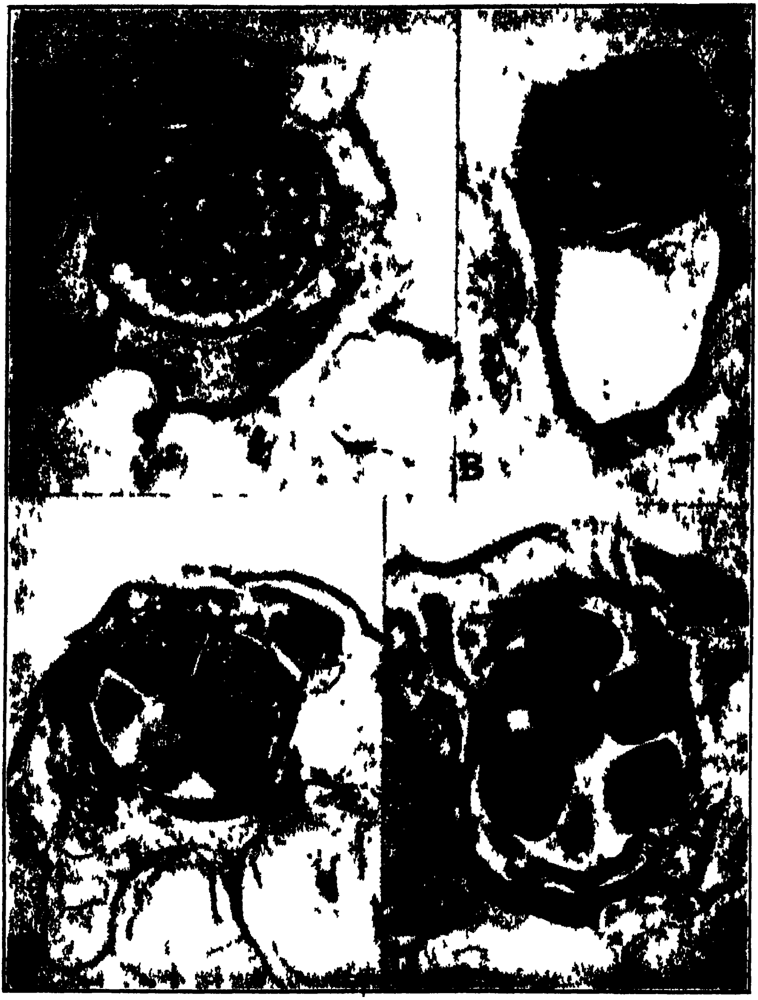

FIG 4 *Synchytrium ranunculi*

The writer wishes to express his thanks to Dr C W Edgerton for making the photographs and to Dr S J P Chilton, Mr Q L Holdeman and Mr F J Reynolds for collecting the material, and to Dr. P. G. Morehead for the Latin descriptions in this and preceding papers.

DEPARTMENT OF BOTANY,
LOUISIANA STATE UNIVERSITY,
BATON ROUGE, LOUISIANA

EXPLANATION OF FIGURES

FIG. 1. *Synchytrium oxalidis*. *A*. Infected plant. *B*. Infected epidermal cell. *C*. Infected cell showing host nucleus. *D*. Infected cell showing host cell material. *E–G*. Compound galls.

FIG. 2. *Synchytrium oxalidis*. *A*. Infected cells showing host material surrounding sori. *B*. Sorus showing first indications of division to form sporangia. *C–D*. More advanced stages.

FIG. 3. *Synchytrium ranunculi*. *A*. Infected leaf and petiole. *B–E*. Early infections. *F*. Infected cell showing surrounding epidermal cells and host cell material surrounding the sorus. *G*. Fungus in substomatal cavity.

FIG. 4. *Synchytrium ranunculi*. *A*. Two sori in infected cell. *B*. First indication of division of sorus to form sporangia. *C–D*. More advanced stages.

IMPROVEMENTS ON THE SOIL BURIAL TESTING METHOD

W. D. Gray and G. W. Martin[1]

(with 5 figures)

The purposes of biological tests as applied to fabrics and other materials which are subject to deterioration brought about by the action of living organisms are: (a) to secure information which will permit a reasonable estimate of the service which may be expected in use, and (b) to indicate the comparative efficacy of substances added to the material to prevent or check the growth of organisms of decay. In many instances it is impossible to predict just what conditions a given article will encounter in service, but if it is intended for use in the moist tropics or in other situations where conditions for decay are favorable, it seems advisable to subject the article to a severe test. No one type of test has yet been devised which can be regarded as ideal. Most of the tests which have been employed in work of this nature involve either the use of pure cultures of selected organisms known to be able to attack the type of material being tested, or else a mixture of organisms, some of which are known to have the same capacity.

The advantages claimed for the pure culture methods are that greater precision is attainable with the techniques used and that there is greater assurance that tests performed in different laboratories, using the same organism and the same substratum and technique, may be correlated with each other more exactly than when other methods are used. The difficulties are the limitations of any single organism when applied to a wide range of material to be tested, the lack of reciprocal effects caused by the presence of other organisms, and the necessity for sterilization.

Mixed-culture tests may involve a mixture of known organisms, grown in pure culture and added to each other in controlled quantity, but more commonly such tests employ a suspension of organisms secured from soil or else the material under test is buried directly in the soil. The papers cited in the bibliography describe these methods and give a number of references to earlier work which need not be repeated here. The present discussion is concerned only with soil burial, and the work of which this is a partial report was done in the Biological Laboratory of the Jeffersonville Quartermaster Depot in 1944 and 1945. Bertolet (2) had previously developed this method and found it extremely useful; his procedures are fully described in the paper cited. When the Biological Laboratory was established, one of its functions was to make a comparative study of various testing methods. A great many methods were tried and it was found that for a very wide range of material, especially textiles, the soil burial method gave the most satisfactory results. However, it was felt that this method could be improved in such a way as to remove or at least minimize the faults which had been attributed to it. These were chiefly two: the seasonal effect when burial was out of doors or even in a greenhouse, and the very great variation in the effect of different soils (5). Both of these faults contributed to the great variation reported by different laboratories when the same type of material was tested by soil burial. Another objection that has been raised against this method is the lack of light, which is reputed to exert a direct effect either on the material under test, *e.g.*, cellulose, or may produce chemical alteration in inhibitors or other materials used in finishing. Wagner, Webber and Siu (6) have shown that exposure to ultra-violet light weakens cotton fibers but at the same time renders them less susceptible to attack by *Metarrhizium glutinosum*. To what extent the pigmentation present in the finish of most articles of equipment likely to be exposed to sunlight would protect them against the effects of light has not been sufficiently investigated. Preliminary exposure to ultra-violet radiation might well be made a part of the soil burial procedure in dealing with certain types of material, but that was not done in the experiments which form the basis for this report. The criticism has been made that the soil burial test is unduly severe; however, this criticism is scarcely valid, since any test which must accomplish in a few days what would require months in service must be correspondingly severe.

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[1] Formerly of Jeffersonville Quartermaster Depot. Publication authorized by Office of Quartermaster General.

VARIATION IN RESULTS OBTAINED FROM GREENHOUSE BURIAL EXPERIMENTS

In greenhouse burial at Jeffersonville, an attempt was made to keep the temperature constant and the soil uniformly moist, since these two factors seem to be of prime importance. Even with experienced workers, however, this was only approximately successful, and the data presented in Table I and fig. 1 demonstrate the results of the variations in environmental factors.

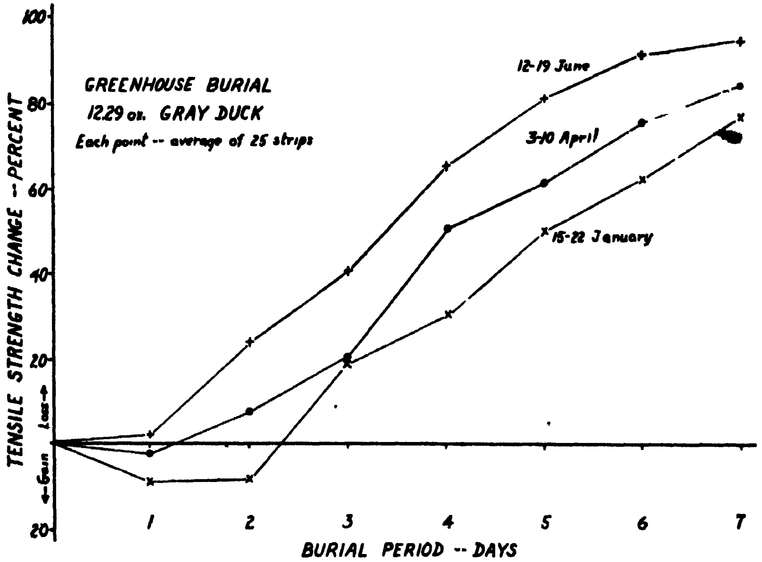

FIG. 1. Seasonal variation in greenhouse burial.

The data in Table I show that with 12.29 oz. gray duck, over seven days were required in January to reduce the breaking strength of standard strips by 80 per cent; six days were required in April and only five days were required in June to cause a comparable reduction in breaking strength. The variations reported here are in accordance with similar experiences encountered elsewhere in greenhouse burial work, and in out-of-door burial such seasonal differences are naturally very greatly intensified. For this reason it was decided to bury test strips in soil under rather closely controlled conditions.

TABLE I

Rate of Loss of Tensile Strength of 12.29 oz. Gray Duck during Greenhouse Burial at Different Seasons *

Days Buried	January 15–22		April 3–10		June 12–19	
	Average Tensile Strength (lbs.)	Per cent Change in Tensile Strength	Average Tensile Strength (lbs.)	Per cent Change in Tensile Strength	Average Tensile Strength (lbs.)	Per cent Change in Tensile Strength
1	177.5	+8.7	178.4	+2.1	166.1	−2.1
2	176.7	+8.3	161.6	−7.6	139.3	−23.8
3	131.8	−19.2	140.2	−19.8	101.6	−40.1
4	104.9	−35.1	95.5	−45.4	57.9	−65.2
5	73.6	−54.9	68.1	−61.1	32.8	−80.6
6	56.6	−64.7	44.4	−74.6	15.5	−90.8
7	33.0	−79.8	28.8	−83.5	11.4	−93.2
Controls	163.2	—	174.8	—	169.7	—

* In Table I and all subsequent tables, unless otherwise stated, each tensile strength figure listed is the average tensile strength of twenty-five test strips.

THE SOIL-PAN BURIAL METHOD

For this method a chamber in which the temperature and relative humidity could be controlled was employed. In all of the work herein reported, the temperature was maintained at 85° F. ± 2° and the relative humidity was maintained at 85% ± 2%. Test strips were buried in stainless steel soil pans which were rectangular in shape with sloping ends, 4 inches deep, 7 × 10 inches on the bottom, 7 × 11 inches at the top, with the upper edges ground level to permit close fitting of the glass plates, 9 × 13 inches in size, used as covers. The test strips used were cut to 1.5 × 5.5 inches, the long dimension being the warp, and were carefully ravelled to a width of one inch. Where FWWR duck (fire, weather, water resistant) or other heavily impregnated fabric was used, the strips were cut exactly one inch in width, care being taken not to cut a warp thread. Five or six such strips were buried in each pan, the pans were then covered with the glass plates and stacked on shelves in the controlled temperature—controlled humidity chamber.

The soil used was fresh compost, made of two parts fertile loam and one part well-rotted cow manure, the whole being carefully mixed and screened. When first used, this compost was rather slow in causing decay, but after four lots of cotton fabric had been buried in it for as many weeks, it attained maximum efficiency and thereafter maintained itself with remarkable constancy, so that the same soil was used over and over.

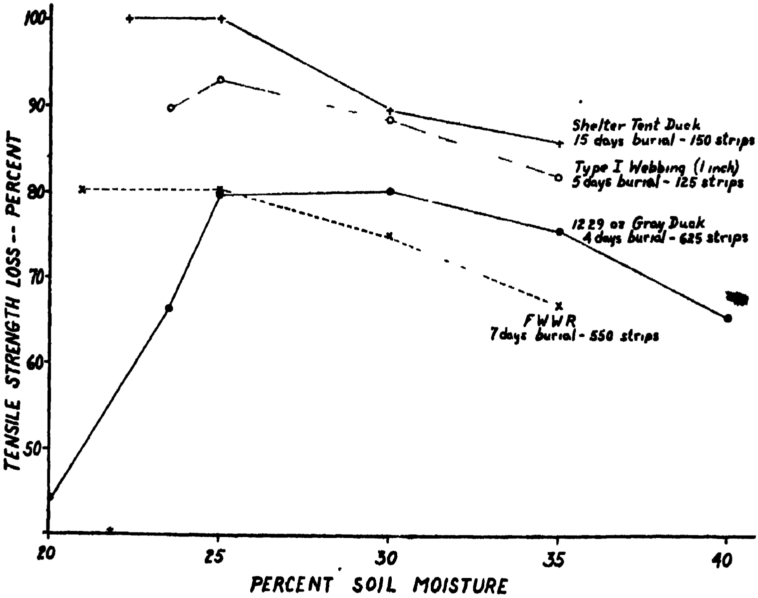

FIG. 2. Relation of soil moisture to decay of different fabrics.

It was suspected that soil moisture content might be an important factor and at first it was thought that the loose-fitting covers of the soil pans might permit the escape of water from the soil. However, preliminary experiments showed that loss of moisture within the ranges studied was not significant for periods of at least five or six weeks. The actual loss of water in five weeks from ten pans selected at random and containing soil, the initial moisture content of which was 25 per cent, varied from 0.87 to 2.28 per cent of the total moisture present. With moisture losses of such low magnitude it was possible to run experiments for a period of several weeks and maintain the soil moisture percentage nearly constant at whatever value it had initially been set. Results of breaking-strength measurements of nearly fifteen hundred test strips which had been buried in soil of varying moisture contents demonstrated that variations in soil moisture induced great variations in rate of loss of tensile strength. Figure 2 shows the relationship of soil moisture content to tensile strength loss of four different fabrics. It should be noted that a soil moisture content of 25 per cent gave a maximum rate of decay for three of the four fabrics tested; only in the case of the heavy gray duck was the rate very slightly, but not significantly higher at 30 per cent moisture content. In the case of shelter-tent duck there was little difference in rate of decay over a moisture range of 22–25 per cent, and with F.W.W.R. duck the rate was about the same over the moisture range of 21–25 per cent. Figure 3 shows the very close approximation between the tensile strength losses of F.W.W.R. duck at 21.3 per cent and 25 per cent soil moisture as compared with the sharp drop in rate of decay when the moisture content was raised to 35 per cent. On the basis of these and other experiments a soil moisture content of 25 per cent, based on the dry weight, was adopted as the standard.

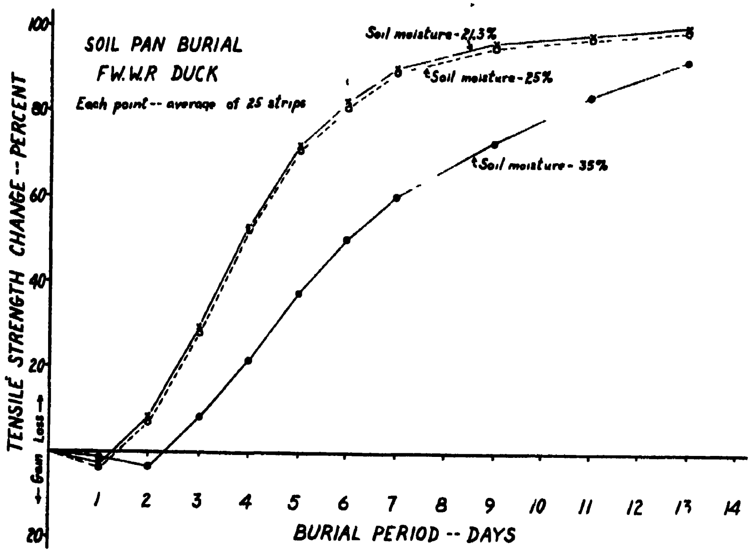

FIG. 3. Effect of varying moisture content on decay of F. W .W. R. duck.

For soils of similar texture, this moisture content should result in nearly maximum rate of decay; however, for soils with dissimilar water-holding capacities, it is quite probable that another moisture value would prove optimum.

Certain irregularities appeared from time to time as may be seen in fig. 4. Shelter-tent duck treated with water repellent and buried in soil of 25 per cent moisture content decayed twice as fast as the same fabric without the water repellent. The nature of the water repellent treatment was unknown; however, it may be that the material used in the treatment actually contained some nutrient substances which were available to the fungi present and acted as growth stimulants. On the other hand, this phenomenon might possibly be explained on purely physical grounds, since the material which contained no water repellent became quite wet when buried in soil and may have been too wet for rapid growth of the fungi involved. Such irregularities appear in any type of test and require individual interpretation, and, where possible and important enough to justify the expenditure of time, comparison with the results of other types of test on the same material.

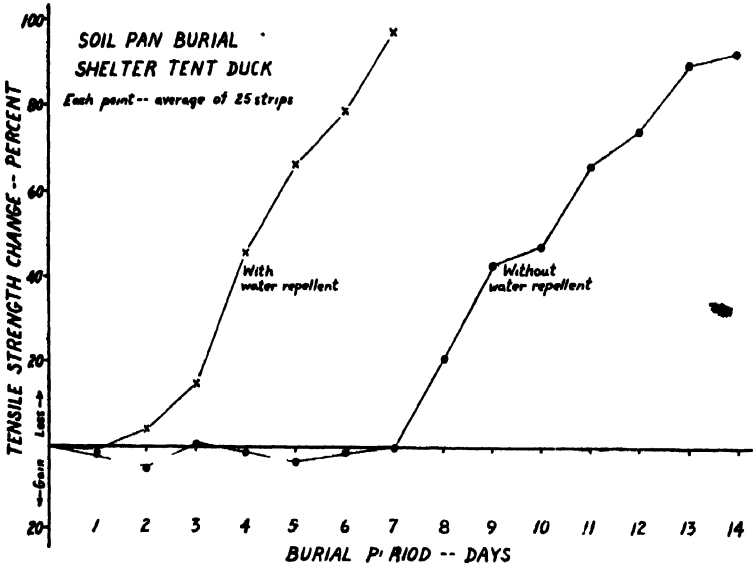

FIG. 4. Effect of repellent on decay of shelter tent duck.

Of more general significance is the effect of leaching. Figure 5 and Table II present the results obtained when F.W.W.R. duck containing 0.35 per cent copper (half as copper naphthenate and half as basic copper oleate) was buried in soil pans and in the greenhouse, with and without preliminary leaching for 72 hours.

TABLE II

COMPARATIVE RATES OF BREAKDOWN OF LEACHED AND UNLEACHED F.W.W.R. DUCK CONTAINING 0.35 PER CENT COPPER (HALF AS COPPER NAPHTHENATE AND HALF AS BASIC COPPER OLEATE) DURING SOIL PAN BURIAL AND GREENHOUSE BURIAL

Days Burial	Percentage Change in Tensile Strength			
	Soil Pans		Greenhouse	
	Unleached	Leached	Unleached	Leached
4	+5.1	−1.9	+2.0	+1.2
8	+4.9	−4.2	+1.6	−3.0
12	+4.8	−49.3	−0.3	−6.3
16	+1.4	−86.4	−18.5	−11.2
20	−2.3	−91.8	−22.4	−22.2
24	+3.1	−99.3	−47.9	−44.9
28	−9.5		−62.8	−52.7
32	−22.3		−72.1	−66.9
36	−35.2		−81.5	−75.6
40	−68.3		−86.8	—
44	−76.9		−94.9	−83.4
48	−87.4		−86.2	
52	−100.0		−68.0	
56	−100.0		−74.8	
60	−100.0		−94.8	

It will be noted that there is little significant difference between the unleached and leached strips in greenhouse burial, whereas in the soil pans the leached fabric was completely destroyed in 24 days while the unleached material did not show a 100 per cent loss in tensile strength until 52 days had elapsed. These results bring out an important difference between greenhouse burial, where the frequent watering provides a leaching effect, and the soil pans, where the limited space and relatively constant soil moisture tend to hold inhibitors in the fabric or in the immediately adjacent soil. It is obvious that when inhibitors are present or are suspected of being present, material to be tested in soil pans should be leached before burial, since fastness to leaching is an important characteristic of an inhibitor. A large number of tests has established a three-day leaching period as ample for practically all types of inhibitor. Even with the added time necessary for such preliminary treatment, the soil-pan burial method is much more rapid in its results than greenhouse burial. In the instance illustrated, which is fairly representative of many other tests, deterioration was approximately twice as rapid in the soil pans as in the greenhouse. Attention may also be called to the much greater regularity of the curves derived from the results of soil-pan burial.

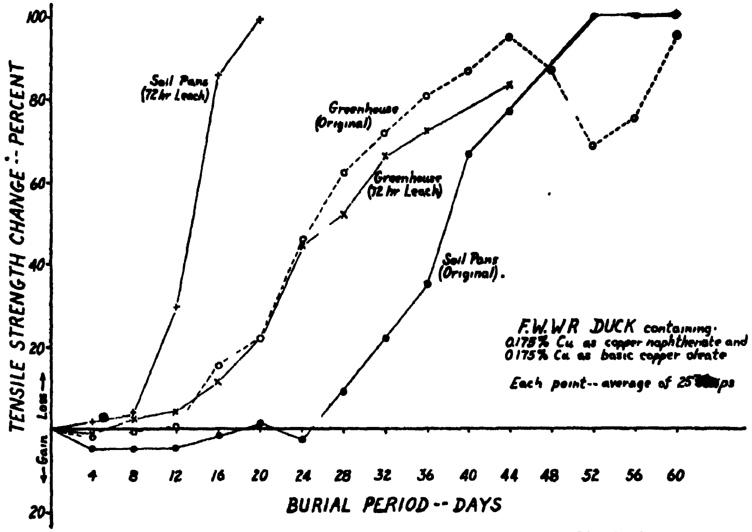

FIG. 5. Effect of leaching on decay of F. W. W. R. duck.

CONCLUSION

With properly prepared and biologically active soil in standard containers where the soil moisture content can be accurately regulated and maintained, and incubation under conditions of closely controlled temperature and relative humidity, soil burial tests of material subject to biological deterioration can be conducted with a high degree of accuracy and reproducibility. Under such conditions, soil burial is a rapid test of great significance, especially when the materials being tested are fabrics.

IOWA STATE COLLEGE,
AMES, IOWA
STATE UNIVERSITY OF IOWA,
IOWA CITY, IOWA

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A SIMPLE AND RAPID METHOD FOR OBTAINING MONOSPORE CULTURES OF FUNGI

LUCILLE K. GEORG

(WITH 2 FIGURES)

The isolation of spores 2–3 μ or larger may be accomplished readily by the use of a small glass conical tip which is attached to the low power objective of the microscope. The larger opening of the cone fits around the lens of the objective (see FIG. 1), and the smaller opening approximates the microscopic field as seen through that lens.

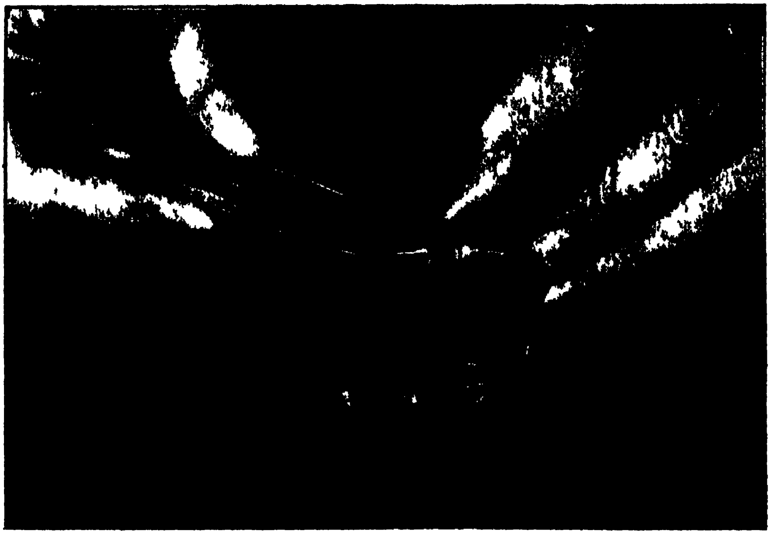

FIG. 1. Glass tips for isolating spores.

Several such conical tips may be drawn out from glass tubing, preferably pyrex. To make the conical tip, glass tubing is selected which has an inside diameter just slightly larger than the diameter of the lens of the low power objective to be used. A small area of the tubing is heated to redness by rotating it in a very hot flame and is then very quickly drawn out so that a steep cone is produced between the original tubing and the drawn out end. This portion can be separated by using a sharp file and breaking at the tip and base of the cone. The following criteria are essential in preparing an accurate tip:

1. The inside diameter of the tubing (which will be the inside diameter of the large end of the finished cone) must be slightly larger than the diameter of the lens of the low power objective so the larger end of the cone will just fit around this lens (approximately 6 to 7 mm. inside diameter).

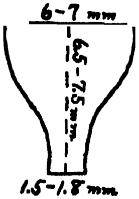

FIG. 2. Measurements of glass tip.

2. The smaller end of the conical tip should have a diameter which approximates that of the microscopic field as seen through the low power objective. For an objective of 8 × magnification used with a 10 × ocular, this field is approximately 1.7 mm. in diameter.

3. The length of the conical tip must be slightly less than the working distance of the objective—*i.e.*, less than the distance between the front lens of the objective and the object on which it is focused. For the 8 × objective used, the working distance is approximately 8 mm. and the conical tips average between 6.5 to 7.5 mm. long (FIG. 2).

METHOD OF SPORE ISOLATION

I. Preparation of a dilute suspension of spores: A dilute suspension of spores is obtained by pouring sterile water onto a well developed culture of the fungus, preferably on a slant of solid medium, and then rotating the tube between the hands or gently shaking for several minutes. A loop of the fluid may be examined to determine whether spores have been washed from the culture. The amount of water to be added will depend on the number of spores that can be washed from the mycelium.

II. Seeding of cornmeal agar plates: Cornmeal agar is used because it is very clear and the spores can be seen quite easily on its surface. Also, it has proved to be a good medium for the germination of the spores studied.

A loop of dilute spore suspension is spread over the surface of a thin cornmeal agar plate. (The agar should not have a depth of more than 2 mm.) Serial plates may be inoculated with the same loop to insure that a plate will be obtained which will have well dispersed spores.

The spores are allowed to germinate at room temperature, and on the second or third day the plates may be opened and examined with the low power lens for sprouting spores. The spores must be so dispersed that areas can be found where only one spore occurs in a microscopic field.

III. Isolation of a single sprouting spore: The low power objective is removed from the microscope and a very thin ring of plasticine is fitted around the lens. A sterile conical glass tip is taken in a forceps and fitted over the lens gently pressing against the plasticine ring to which it will adhere (see FIG. 1). The objective is then returned to the microscope and focused on the surface of the agar. When a field is found where only one spore is present, the spore is centered in the microscopic field, and the objective is carefully lowered so that the small end of the conical tip will cut through the agar and form a ring around the spore. The objective is raised and the small disc of agar within the cut circle must be carefully examined to determine that only one spore is present in this area. The area just outside the circle should also be examined so that there is no danger of contamination by another spore which may lie just outside. The disc of agar is then removed from the plate using a fine flattened sterile needle and is placed right side up on a fresh plate of medium of a type which will support good growth of the organism under study. This plate may then be examined in order to determine that the spore has actually been transferred on the small disc of agar. The plate may be further examined on successive days to make sure that only one spore is growing on the plate.

The glass tip may be resterilized by removing it from the objective and holding it in the flame for a few seconds. When it cools it may be reattached and another spore isolated.

This method has proved to be successful for obtaining monospore cultures of Trichophytons.

COLLEGE OF PHYSICIANS AND SURGEONS,
COLUMBIA UNIVERSITY

HAPLOSPORANGIUM IN CANADIAN RODENTS[1]

Eleanor Silver Dowding[2]

In 1942 Emmons (1) described *Haplosporangium parvum* which he isolated from the lungs of wild Arizona rodents. *H. parvum* is a Phycomycete which on artificial media grows as a septate mycelium bearing single-spored sporangia, and in the lung appears as a large thick-walled oval or spherical cell (chlamydospore).

During the summer of 1946, collections of the lungs of wild rodents were made in Western Canada[3] over an area of about 1000 square miles extending from Lethbridge to Peace River. Two hundred and seventy-five animals (nine species) were collected, one portion of the lung of each animal being preserved and another portion being planted in Sabouraud's medium.

It was found that fourteen animals possessed fungous cells in their lungs. The hosts were thirteen white-footed deer-mice (*Peromyscus maniculatus borealis*) and one red squirrel (*Sciurus hudsonicus baileyi*). From the lungs of eight of these infected animals *Haplosporangium parvum* was obtained in culture. The range of *Haplosporangium parvum* has therefore been extended into Western Canada, and two new hosts have been reported—the common white-footed mouse, and the red squirrel.

In Arizona the largest *Haplosporangium parvum* cell recorded within the lung was 45 μ in diameter. In Alberta the chlamydospore may reach the relatively enormous dimensions of 270 μ and its wall may be 8–10 μ thick.

Fungous cells in Canadian rodent lungs have never been observed to contain endospores. Some of the cells in Arizona rodent lungs were filled with endospores (2). Since the Arizona rodents were known to be infected with *Coccidioides immitis* as well as with *Haplosporangium parvum,* and since no coccidioidal infection was encountered in our Canadian rodent survey, it would seem possible that the endosporulating cells in the Arizona material were those of *C. immitis* and not of *H. parvum.*

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[1] This investigation was made possible by financial assistance from the National Research Council of Canada.

[2] Mrs. E. S. Keeping.

[3] Collections were made by the Field Survey of the Division of Entomology of the Province of Alberta.

Haplosporangium parvum has been cultivated upon soil in the Provincial Laboratory. It grows vigorously upon this medium and produces sporangia. It was found that the sporangia could not be shed by jarring the culture nor could they be dispersed by air currents. They are adhesive and are readily transferred by contact. It may be inferred from these observations that the fungus naturally grows upon soil. There burrowing rodents come into contact with it, and carry away the adhesive sporangia on their faces. When the animals clean themselves with their paws, the sporangia may be inhaled.

Although the spores can readily be induced to germinate at room temperature, yet at 37° C. no germination takes place. The sporangia merely swell. After three weeks of incubation they become as much as ten times their original diameter and are then large thick-walled chlamydospores resembling those found naturally in the mouse lung, although about one-fifth the size. These chlamydospores when removed from the incubator and transferred to soil-agar germinate within two days, producing a number of radiating germ-tubes. It may be inferred from these observations that the sporangium, after it is inhaled by the mouse, swells within the lung to form a large thick-walled chlamydospore which after the death of the animal germinates in the soil and so initiates the saprophytic phase.

A detailed account of the work will be published shortly (3).

PROVINCIAL LABORATORY,
UNIVERSITY OF ALBERTA,
EDMONTON, ALBERTA

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NOTES AND BRIEF ARTICLES

Coprophilous Ascomycetes of Virginia

Dung was collected from pastures, open woods, barns and manure piles in the following counties: Albemarle, Augusta, Campbell, Clark, Giles, Montgomery, Norfolk, and Nottoway. Some of it was old and weathered, some several days old, and some freshly dropped. The dung was placed in pans lined with moist paper towels. Dry dung was moistened with water, and water was added to the cultures from time to time to prevent their drying out. They were kept in diffused light at room temperature. The pans were covered with glass panes to prevent rapid evaporation and also to protect the cultures. Rabbit and deer mouse dung, consisting of small balls, was placed in Petri dishes to facilitate handling.

At intervals of two to three days a portion of dung was removed from the culture pan and examined under a wide field binocular microscope. Ascocarps were lifted from the dung with dissecting needles and mounted on slides in a 10 per cent glycerine solution. Old, weathered dung from open fields produced more ascocarps than fresh dung or dung that had been packed in manure piles. It was necessary when mounting the hairy perithecia of *Chaetomium* to use first a solution of alcohol, glycerine, and water to avoid capturing air bubbles in the hairs of spore masses. After a few minutes this solution was drained off and the glycerine solution added. The specimens were then identified and catalogued.

The following thirteen genera and sixty species of coprophilous Ascomycetes have been observed.

DISCOMYCETES

Ascobolus americanus (Cook & Ellis) Seaver. On horse dung, Charlottesville, April 1, 1942. *A. geophilus* Seaver. On horse dung, Charlottesville. *A. glaber* Pers. On horse dung, Charlottesville, January 21, 1942. Also found on horse dung collected at Boyle, Mississippi. *A. immersus* Pers. On horse dung from Charlottesville, Norfolk, and Blandy Farm (Boyce, Va.), November 12, 1941. *A. Leveillei* Boud. On horse dung from Charlottesville, January 19, 1942. *A magnificus* Dodge. On cow dung from Charlottesville, February 9, 1942. *A. stercorarius* (Bull.) Schröt. On cow and horse dung from Blackstone, Charlottesville, Norfolk and Blandy Farm, November 12, 1941. *A. striisporus* (Ellis & Dearn.) Seaver. On horse dung, Charlottesville. *A. viridulus* Phill. & Plow. On rabbit dung from Elliott Knob, May 25, 1942. *A. Winteri* Rehm. On horse dung, Charlottesville, November 28, 1941. *Saccobolus Kerverni* (Crouan) Boud. On horse dung from Charlottesville, Norfolk, and Blackstone, November 11, 1941. *S. violascens* Boud. On horse dung, Norfolk, January 31, 1942. *Ascophanus argenteus* (Curr.) Boud. On horse dung from Charlottesville. *A. carneus* (Pers.) Boud. On cow dung from Lynchburg, April 3, 1942. On rabbit dung from Elliott Knob, May 25, 1942. *A. lacteus* (Cooke & Phill.) Sacc. On horse dung, Charlottesville, May 27, 1942. *A. vicinus* Boud. On horse dung, Charlottesville, January 19, 1942. *Ryparobius crustaceus* (Fuckel) Rehm. On horse dung, Charlottesville. *R. sexdecimsporus* (Crouan) Sacc. On horse dung, Charlottesville, May 14, 1942. *Thecotheus Pelletieri* (Crouan) Boud. On horse dung, Lynchburg, June 3, 1942. *Lasiobolus equinus* (Müll.) Karst. On horse dung, Charlottesville, March 30, 1942. *Peziza fimeti* (Fuckel) Seaver. On cow dung, Charlottesville. *P. vesiculosa* Bull. ex Fr. On cow dung. Charlottesville, January 31, 1942.

PYRENOMYCETES

Chaetomium ampullare Chivers. On rabbit dung, Elliott Knob, June 5, 1942. *C. bostrychodes* Zopf. On horse dung from Norfolk, May 20, 1942. Also on deer mouse dung from Mountain Lake. *C. caprinum* Bainier. On rabbit dung, Elliott Knob, June 4, 1942. *C. crispatum* Fuckel. On rabbit and horse dung, Charlottesville, November 17, 1942. *C. globosum* Kunze. On horse dung, Norfolk, May 16, 1942. *C. murorum* Corda. On horse dung, Norfolk, May 18, 1942; Radford, May 7, 1942. *C. sub-*

spirale Chivers. On rabbit dung, Elliott Knob, May 27, 1942. *Sordaria fimicola* (Rob.) Ces. & DeNot. On horse and cow dung, Charlottesville. *S. humana* (Fuckel) Awd. On horse dung from Radford, April 27, 1942; also from Norfolk. *S. leucoplaca* (B. & R.) E. & E. On horse dung, Charlottesville, April 21, 1942. *S. macrospora* Awd. On horse dung, Charlottesville, January 24, 1942; Lynchburg, April 1, 1942; Blandy Experimental Farm, April 27, 1942. *S. minima* (Sacc. & Speg.) Sacc. On horse dung, Charlottesville, April 9, 1942. *Pleurage adelura* Griffiths. On horse dung Charlottesville, April 13, 1942. *P. albicans* (Alb. & Schw.). On horse and cow dung, Charlottesville. *P. amphicornis* (Ellis) Kuntze. On rabbit dung, Charlottesville, May 25, 1942. *P. anomala* Griffiths. On horse dung, Norfolk, January 13, 1942; Lynchburg, April 1, 1942. Griffiths and Seaver (1910) indicate it as known only from the type locality, New York. *P. anserina* (Rabh.) Kuntze. On horse dung, Norfolk, April 1, 1942. On horse dung, Lynchburg and Charlottesville. Also found on horse dung from Boyle, Mississippi. *P. arachnoidea* (Niessl.). On rabbit dung, Charlottesville, May 8, 1942. *P. collapsa* Griffiths. On horse dung, Charlottesville, March 14, 1942; also on rabbit dung from Elliott Knob. *P. conica* (Fuckel) Griffith & Seaver. On rabbit dung, Elliott Knob, June 5, 1942. On cow dung, Lynchburg, April 3, 1942. *P. curvicolla* (Wint.) Kuntze. On rabbit dung from Charlottesville and Elliott Knob, May 8, 1942; also on horse dung from Charlottesville. *P. dakotensis* Griffiths. On horse dung, Charlottesville, May 8, 1942. *P. decipiens* (Wint.) Kuntze. On horse dung from Charlottesville, May 8, 1942. *P. erostrata* Griffiths. On horse dung from Charlottesville, May 6, 1942, and from Norfolk. Also found on horse dung collected by Mr. C. W. Merritt from Boyle, Mississippi, January 15, 1942. *P. fimiseda* Ces. & DeNot. On horse dung from Radford, June 5, 1942. *P. minuta* (Fuckel) Kuntze. On horse dung from Blandy Experimental Farm, April 29, 1942. *P. pleiospora* (Wint.) Kuntze. On cow dung from Charlottesville. *P. taeniodes* Griffiths. On horse dung, Charlottesville, November 24, 1941; Lynchburg, March 30, 1942. *P. vestita* Zopf. On horse dung, Charlottesville, March 14, 1942; Lynchburg, April 10, 1942; Blackstone, May 1, 1942. *P. zygospora* (Speg.)

Kuntze. On horse dung, Charlottesville, November 18, 1941. *Hypocopra gigaspora* E. & E. On cow dung, Charlottesville. *Delitschia leporina* Griffiths. On horse dung, Charlottesville *Sporormia chaetomioides* Griffiths. On horse dung, Lynchburg, May 2, 1942. *S. corynespora* Niessl. On cow dung, Charlottesville. *S. herculea* E. & E. On horse dung, Lynchburg, May 2, 1942. *S. intermedia* Awd. On horse dung, Charlottesville, April 13, 1942; Blandy Experimental Farm, April 27, 1942. *S. leporina* Niessl. On horse dung, Charlottesville, November 11, 1941. *S. minima* Awd. On horse dung Charlottesville, November 11, 1941.

The author wishes to thank Dr. E. M. Betts, University of Virginia, under whom this paper was worked out, and also the numerous contributors of material collected all over the state.—CHARLES MAYE WILSON, University of Virginia.

NOTICE

The annual foray of the Mycological Society will be held at Highlands, North Carolina, Sept. 2–7. Write to Prof. J. H. Miller, Dept. of Plant Path., Univ. of Georgia, Athens, Ga., in regard to accommodations. Please give the number in your party and length of stay.—ALEXANDER H. SMITH.

MYCOLOGIA

OFFICIAL ORGAN OF THE MYCOLOGICAL SOCIETY OF AMERICA

VOL. XXXIX JULY–AUGUST, 1947 No. 4

THREE NEW SPECIES OF ZOÖPAGE PREDACEOUS ON TERRICOLOUS RHIZOPODS

CHARLES DRECHSLER[1]

(WITH 7 FIGURES)

The genus *Zoöpage* was erected to include zygomycetous forms that in their vegetative stage capture microscopic animals through adhesion to aseptate mycelial hyphae, and that in their asexual reproductive stage give rise to chains of aerial conidia. Its predaceous mycelial habit, though not its catenulate sporulation, is shared in the Zoöpagaceae by the three genera *Acaulopage, Stylopage,* and *Cystopage*. On the other hand the endoparasitic genus *Cochlonema* and the ectoparasitic genus *Bdellospora* share its catenulate sporulation but differ markedly in outward form of the vegetative thallus. Of the seven species of *Zoöpage* that I have had occasion to describe earlier, six—*Z. atractospora* (**2**: 378–381), *Z. cladosperma* (**2**: 384–387), *Z. mitospora* (**4**: 137–140), *Z. nematospora* (**2**: 381–384), *Z. phanera* (**1**: 26–30), and *Z. thamnospira* (**4**: 141–144)—subsist by capture of *Amoebae*, whereas the seventh, *Z. tryphera* (**3**: 241–244), subsists by preying habitually on a testaceous rhizopod. Three fungi are set forth in the present paper as new members of the genus; two of them capturing *Amoebae*, whereas the third, a species remarkable especially for

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[1] Pathologist, Division of Fruit and Vegetable Crops and Diseases, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration, United States Department of Agriculture, Plant Industry Station, Beltsville, Maryland.

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the hyphomycete-like appearance of its conidia, captures a testaceous rhizopod.

A NARROW-SPORED ZOÖPAGE CAPTURING TWO SPECIES OF AMOEBA

Several maizemeal-agar plate cultures which, after being permeated with mycelium of *Pythium ultimum* Trow, were further planted with small quantities of partly decayed leaves of *Phragmites communis* Trin. collected near Madison, Wisconsin, on November 20, 1945, revealed in eight days capture of numerous individual amoebae through adhesion to meagerly branched aseptate hyphae varying commonly from 1 to 1.8 μ in width. The captured animals measured 10 to 40 μ across when drawn into a somewhat rounded form. Their finely granular transparent protoplasm was surrounded by a thin, firm pellicle which frequently was in part minutely rippled and in part was disposed in a rather smoothly undulating contour about broadly protruding pseudopodia. All newly captured specimens contained a single subspherical or prolate ellipsoidal nucleus in which a relatively large mass of clear, highly transparent material surrounded a smaller quantity of slightly darker material. This darker material sometimes was present as a globose central body or endosome (FIG. 1, *A, a–d; B*), and at other times was divided among about twelve oblate ellipsoidal bodies that were distributed in scattered positions close under the nuclear membrane (FIG. 1, *A, e, f; C, a, b; D, a*). From their different nuclear organization the animals were obviously referable to two separate species of *Amoeba* which in their morphology corresponded very closely to the two species earlier reported as being habitually captured and consumed by my *Acaulopage ischnospora* (10). The correspondence, indeed, left no doubt that the same two species were concerned here as had been concerned in the cultures of *A. ischnospora* prepared with plant detritus originating from a locality more than 150 miles from Madison. Since predaceous attack, and, for that matter, also parasitic attack, on different rhizopods is not often observable among members of the Zoöpagaceae, utilization of the same two species of *Amoeba* by both *A. ischnospora* and the present fungus would seem to indicate exceptional similarity in the animals with respect to composi-

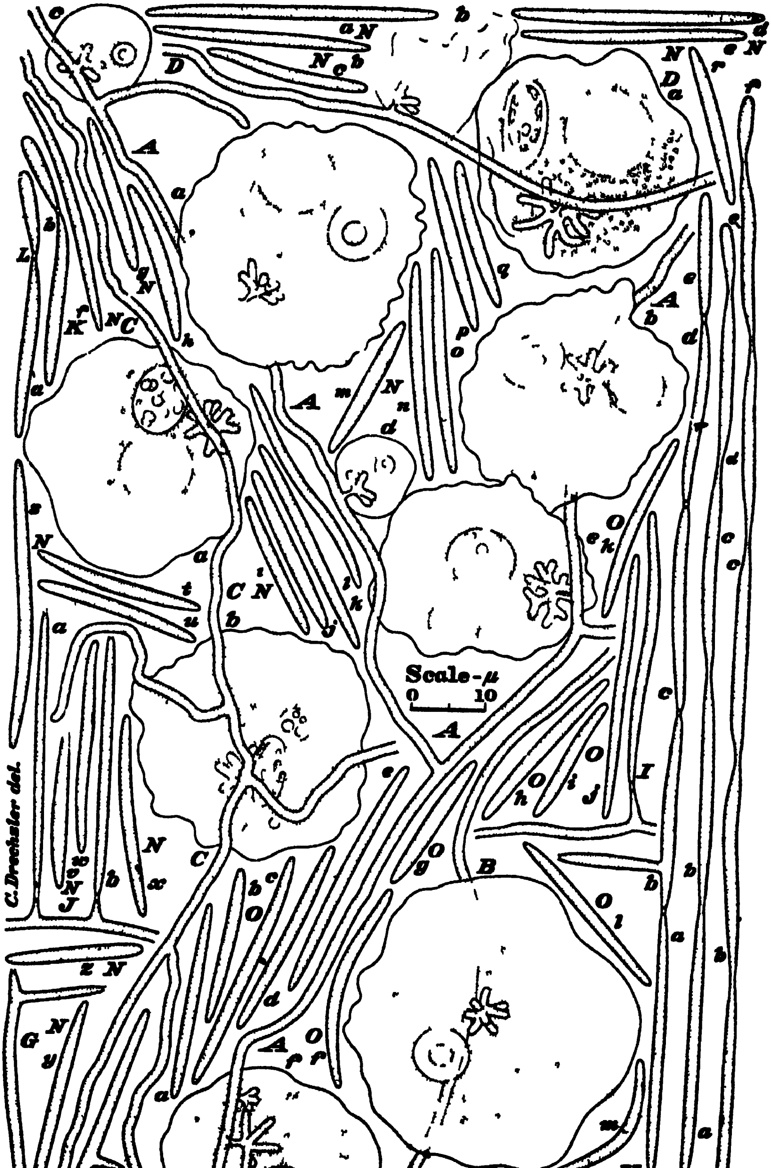

Fig. 1 *Zoopage virgispora*

tion of pellicle and protoplasm despite very evident differences in their nuclear organization.

Following capture of an indivdual amoeba its pellicle was penetrated by a narrow process extended from the adhering hyphal filament. After elongating a few microns this process would widen abruptly and bifurcate repeatedly to form a pedicellate haustorium, which like the similar organ in *Acaulopage ischnospora* bore short assimilative branches of about the same width as the mycelial hyphae. Usually only a single haustorium was formed (FIG. 1, *A, a–e; B; C, a, b; D, a, b*), but sometimes as many as three were intruded into an animal (FIG. 1, *A, f*) to expropriate its contents.

Expropriation of protoplasm was at the beginning not accompanied by any noticeable injury in specimens of the *Amoeba* whose nucleus contains the single central body, for the nucleus here retained its normal appearance and the contractile vacuole continued to operate briskly until the granular contents were reduced to perhaps one-third of their original quantity. Many individuals of the other *Amoeba*, however, showed at a relatively early stage of expropriation rather pronounced lengthening and narrowing of the nucleus, together with irregular deformation of the peripheral bodies (FIG. 1, *C, b; D, a*). It appears uncertain whether this deformation of the nucleus came about primarily as a result of invasion by the fungus, or perhaps was encouraged by the conditions—such as strong illumination and diminished air supply under a cover glass—usually attending close microscopical examination. Similarly early nuclear degeneration was not noted before when the same *Amoeba* was found subjected to predaceous attack by *Acaulopage ischnospora*, by *A. tetraceros* Drechsl. (8: 289–291), and by *Zoöpage thamnospira*. After captured animals of either species succumbed, expropriation of their contents continued (FIG. 1, *D, b*), until only the empty pellicle remained. Thereupon, as in related forms, the haustorium was evacuated through withdrawal of its contents backward into the parent hypha, leaving its empty membranous envelope to vanish like the pellicle surrounding it.

Thus amply nourished the fungus reproduced asexually in abundance by giving rise here and there from prostrate hyphae to erect or ascending aerial filaments, which, though for the most part of the same width as the mycelial threads, were constricted to about one-third of this width at intervals varying usually from 15 to 40 μ (FIG. 1, *E, F*); the lowermost constriction coming usually at a height of 2 to 6 μ (FIG. 1, *E, F, G*). On cessation of growth the wider portions of the filaments (FIG. 1, *E, a–e; F, a–f*) were delimited as conidia through evacuation of each narrow isthmus, and deposition of a retaining wall at both ends of the emptied tubular connection (FIG. 1, *H, a–e; I; J, a, b; K, a, b; L, a, b*). The number of conidia formed in a uniaxial chain varied commonly from five to ten, but additional spores were often produced in a lateral chain attached to a spur extending at a wide angle from the lowermost conidium (FIG. 1, *G*), or from the conidium immediately above the lowermost one (FIG. 1, *H, b*). Apparently the lowermost conidium was often delimited proximally somewhat later than other members of the chain, since it was frequently found continuous with the mycelium (FIG. 1, *G*) when all of its fellows had already become detached. After its tardy delimitation from the tapering sterigma it yet appeared as a rule distinguishable from spores of more distal origin by reason of its greater length and lesser width—in fine, by reason of its more pronouncedly filamentous shape (FIG. 1, *H, a; I; J, a, b*). The terminal conidium (FIG. 1, *H, e; K, b; L, b*), on the other hand, was often noticeably shorter than the conidia formed below it (FIG. 1, *H, a–d; K, a; L, a*), besides being distinguished frequently by a more nearly clavate shape. Although occasionally the conidial chains were borne on sterigmata less than 10 μ apart (FIG. 1, *J, a, b*) the intervals between sterigmata were usually many times greater. Sporulation, nevertheless, was so abundant that after disintegration of the chains the detached conidia were strewn thickly over the substratum, and then offered a display reminiscent of the detached conidia of *Acaulopage ischnospora,* owing mainly to a general similarity of shape that presumably derives from like adaptation for predaceous attack on the same two rhizopods. On more careful examination the conidia of the catenulate fungus showed trustworthy distinguishing features in their occasionally branched condition (FIG. 1, *M, a, b*), their lesser length, and their lack of empty appendages (FIG. 1, *N, a–z; O, a–p*). The catenulate conidia further showed considerable similarity in outward form to the solitary conidia of my *A. stenospora* (**7**: 254, 256–258); and this similarity, too, may derive from adaptation to a like biological relationship, since the *Amoeba* captured by that fungus has a nucleus with a central body, and therefore might be identical with one of the two rhizopods found destroyed in the cultures planted with decaying *Phragmites* leaves. No close resemblance in conidial morphology was discovered through comparison with previously described species of *Zoöpage*, for all these differ markedly either with respect to dimensions, or to shape, or to presence of warty sculpturing. The catenulate fungus from Wisconsin is accordingly described as a new species under an epithet having reference to the rod-like conformation of its conidia.

Zoöpage virgispora sp. nov.

Mycelium effusum; hyphis continuis, incoloratis, filiformibus, parce ramosis, plerumque 1–1.8 μ crassis, ad animalia minuta inhaerentibus, pelliculam eorum perforantibus, haustorium (interdum 2 vel 3 haustoria) intus evolventibus quod protoplasma exhaurit; haustorium pediculatum, pediculo 2–4 μ longo, 0.6–1 μ crasso, apice abrupte latescente, vulgo bis vel ter repetite bifurco, itaque saepius 4–8 ramulos assumentes divaricatos 2–6 μ longos 1.1–1.4 μ crassos ferente. Conidia continua, incolorata, levia, saepius baculiformia, utrimque leniter attenuata, interdum filiformia aut clavata, nonnunquam ramo praedita, 11–41 μ longa, 1.2–2.2 μ crassa, in catenulis oriunda; catenulis ex apice sterigmatis erecti 2–6 μ longi ascendentibus, saepius simplicibus sed interdum ramosis, vulgo in 5–10 sporis constantibus.

Amoebas duarum specierum 10–40 μ latas capiens consumensque habitat in foliis *Phragmitis communis* putrescentibus prope Madison, Wisconsin.

Mycelium spreading; vegetative hyphae continuous, colorless, filamentous, rather sparingly branched, mostly 1 to 1.8 μ wide, capturing minute animals through adhesion, then narrowly perforating the pellicle of each captive and intruding a haustorium (or sometimes 2 to 3 haustoria) to assimilate the protoplasmic contents. Haustorium pedicellate, the pedicel usually 2 to 4 μ long, 0.6 to 1 μ wide, abruptly enlarging distally and bifurcating 2 or 3 times at wide angles, thus bearing usually 4 to 8 assimilative branches 2 to 6 μ long and 1.1 to 1.4 μ broad. Conidia continuous, colorless, smooth, most often rod-shaped, tapering noticeably toward both ends, sometimes filamentous or clavate, sometimes bearing a branch at nearly a right angle, mostly 11 to 41 μ long, 1.2 to 2.2 μ wide, formed in chains; the chains mostly simple and containing 5 to 10 spores, but sometimes branched and then containing often 10 to 15 spores altogether, in either case ascending from an erect sterigma usually 2 to 6 μ long.

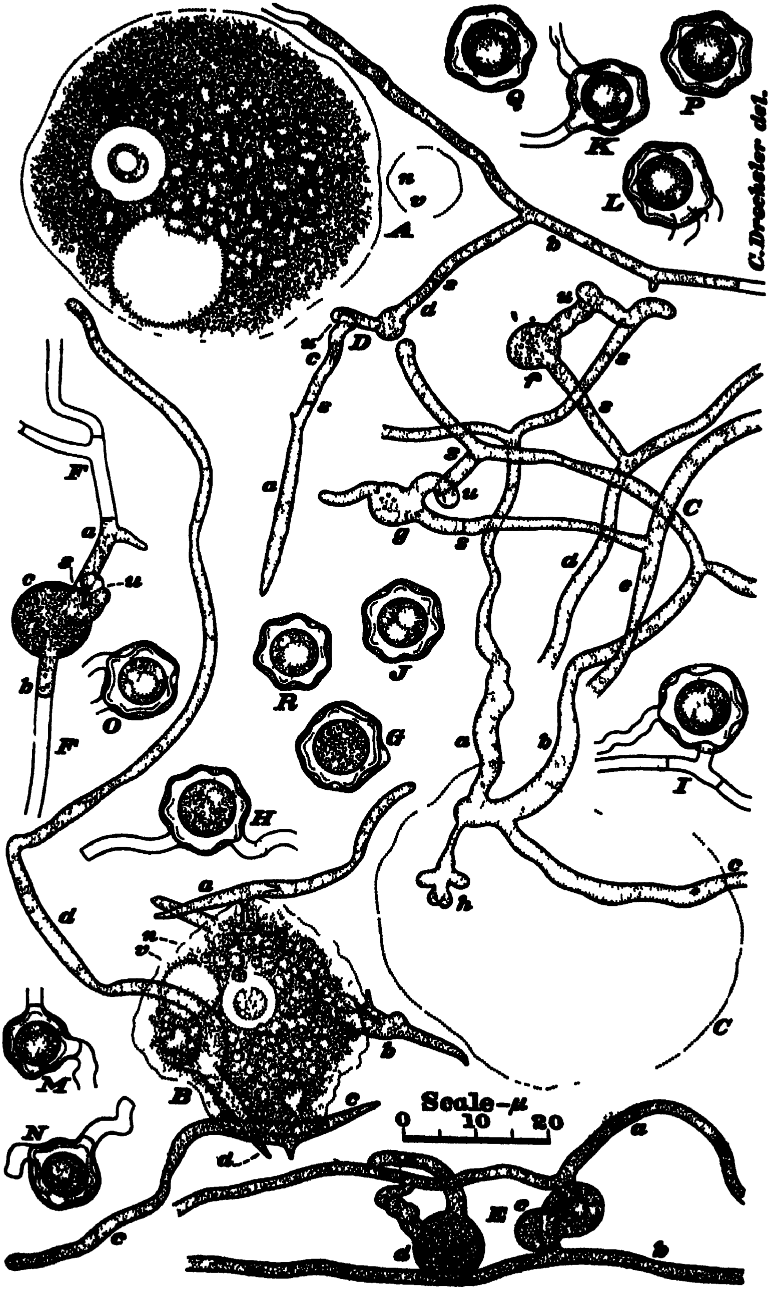

FIG 2 *Zoopage pachyblasta*

Capturing and consuming *Amoebae* 10 to 40 μ wide that belong to two species, it occurs in decaying leaves of *Phragmites communis* near Madison, Wisconsin.

A ZOÖPAGE WITH CONIDIA THAT OFTEN HAVE WIDE GERM HYPHAE

A number of soft maizemeal-agar plate cultures which, after being permeated with mycelium of *Pythium ultimum* Trow, had been further planted by adding small quantities of partly decayed potato-vine (*Solanum tuberosum* L.) detritus collected near Greeley, Colorado, early in October, 1945, soon became abundantly inhabited by an *Amoeba*, mostly 25 to 50 μ wide, which when examined under a microscope of high magnification did not appear to be surrounded by a distinct pellicle. Should an outer membrane corresponding to a pellicle have been present it must have been too thin to be clearly discernible. The transparency of the animal's protoplasm was greatly reduced by numerous ingested bodies, which in some instances could readily be recognized as fungus spores (FIG. 2, *A*), but in other instances seemed of rather ambiguous character (FIG. 2, *B*; FIG. 3, *A*). Very often the opaque ingested material completely hid the single nucleus of the rhizopod. Where, however, pseudopodial movement had brought the nucleus into a favorable position on the upper side of the animal, it was revealed as a globose body, about 7 to 11 μ wide (FIG. 2, *A*, *n*; *B*, *n*; FIG. 3, *A*, *n*), consisting of a clear homogeneous outer layer and a subspherical central endosome; the endosome offering a somewhat darker appearance, except for a clear vacuole enclosed by it (FIG. 2, *A*, *n*; FIG. 3, *A*, *n*).

When the soft agar cultures were examined fourteen days after the potato-vine detritus had been added, numerous specimens of the *Amoeba* were found undergoing destruction by a species of *Zoöpage* whose branched conidial chains appeared more or less interlaced in nearly horizontal postures to form a scanty arachnoid aerial weft (FIG. 3, *B*). In following the branched chains backward they were found arising from aseptate filaments that came from scattered animals in various stages of disintegration (FIG. 3, *B*, *a–c*). While the aseptate filaments for the most part measured about 1.7 μ in width, they often showed distally one or more constrictions whereby hyphal portions (FIG. 3, *C*, *a*; *D*, *a*) were set

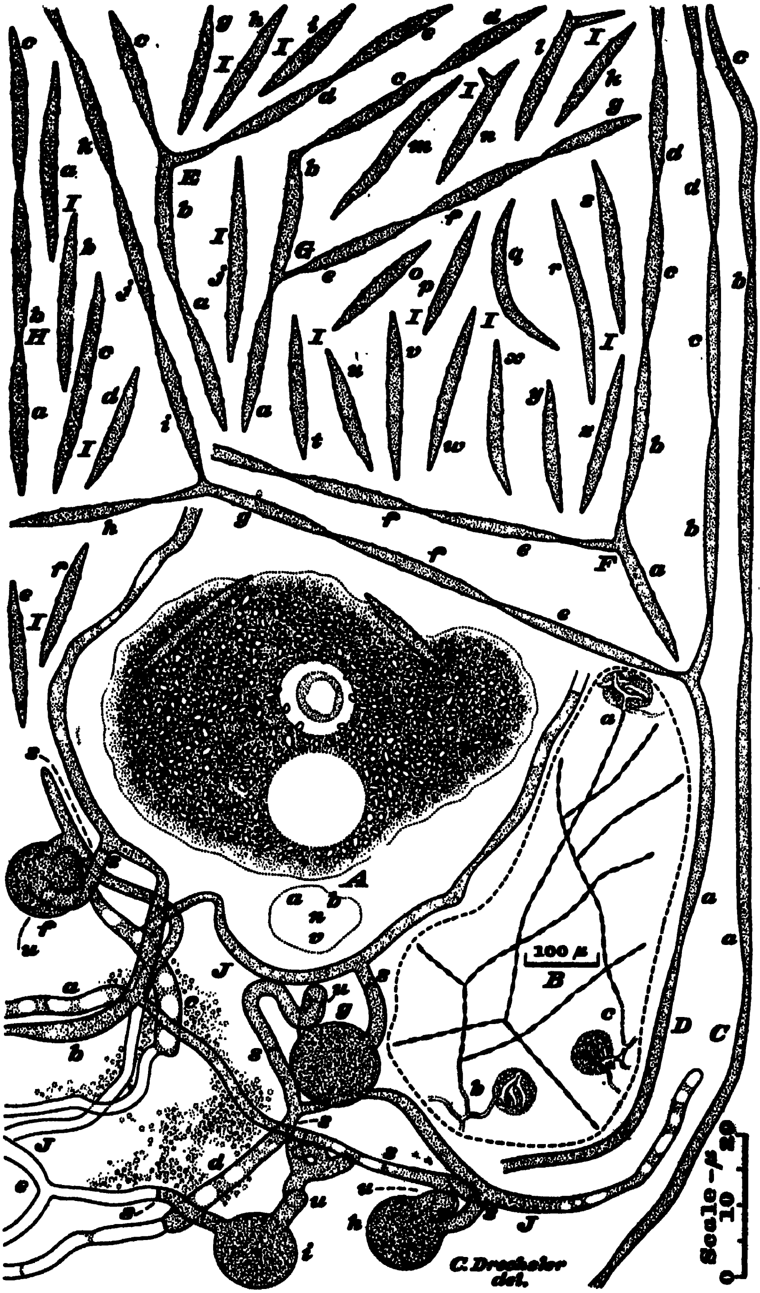

FIG. 3. *Zoöpaga pachyblasta.*

off, generally similar to the adjacent conidia (FIG. 3, *C, b, c*), as these likewise frequently attained lengths from 40 to 50 μ, and as a rule, even when measuring only about 25 μ (FIG. 3, *D, b–e*), were smooth externally. Above the few poorly differentiated proximal conidia all members of a conidial chain (FIG. 3, *D, f–k; E, a–e; F, a–f; G, a–g; H, a–c*) were found ornamented with many verrucose protuberances that appeared conspicuous when the spores were viewed in air bubbles. Since a chain often contained twenty to thirty-five members in a uniaxial series, and in addition frequently bore one or two branches, each of three to fifteen spores, it is not surprising that detached conidia in a random assortment (FIG. 3, *I, a–z*) showed usually so strong a preponderance of verrucose specimens that the few intermixed smooth specimens (FIG. 3, *I, r*) were hardly noticeable. Conidial chains usually bore their branches at wide angles; the branches arising from distal and medial positions in the axial series as well as from proximal positions. The lateral spur supporting a branch seemed to arise somewhat more often near the distal end of a conidium (FIG. 3, *D, g; E, b; F, a; I, l, n*) than near the basal end (FIG. 3, *G, b*). In tapering toward the narrow isthmuses between members of a chain, the conidia showed generally an elongate fusiform shape rather similar to the shape of the conidia of *Z. atractospora*. On disintegration of the chains the spores were left strewn about thickly on the moist substratum. When a roving specimen of the susceptible *Amoeba* species came in contact with them they adhered to the animal (FIG. 3, *A, a, b*). Such adhering spores commonly germinated by putting forth individually a germ-tube (FIG. 2, *B, a, b*) which near its origin soon attained a width—often 3.5 to 4 μ—about twice their own (FIG. 2, *B, c, d*), though in extending itself well beyond the animal, whether on or into the agar substratum, it conformed to the usual width of mycelial hyphae generally. At the same time that each adhering conidium was putting forth a germ-tube it was also intruding into the protoplasm of the animal a haustorium which in an early stage consisted usually of a slender stalk with a swollen termination (FIG. 2, *B, b*) or with two stout divergent lobes (FIG. 2, *B, a, c, d*). On further bifurcation the haustorium in later stages was often found bearing four assimilative lobes (FIG. 2, *C, h*).

Although the proximally widened germ-tube coming from an adhering conidium may properly be held distinctive of the fungus, the extraordinary width here is probably not a special attribute of germ-tubes, but rather a general attribute of adhering vegetative hyphae. As a rule when an attack was well advanced the *Amoeba* was found closely beset over a considerable portion of its surface with conspicuously widened hyphal ramifications (FIG. 2, *C, a–c*) that in many instances seemed to be of mycelial origin as they lacked the pointed spurs wherein the tapered ends of a conidium usually remained recognizable. The widening of hyphal elements may perhaps be best interpreted as an adaptational feature which, by providing increased adhesive surface, makes for greater effectiveness in holding rhizopods whose lack of a firm pellicle must make them unusually elusive. In instances where a detached conidium (FIG. 2, *D, a*) collaborated with a mycelial filament (FIG. 2, *D, b*) to give rise to a pair of conjugating gametangia (FIG. 2, *D, c, d*), the gametangium contributed by the conidium (FIG. 2, *D, c*) was borne on a germ-tube of ordinary width.

Units of sexual reproductive apparatus derived jointly from a conidium and a mycelial filament showed much the same relationship of parts as was displayed in similar units, for example, of *Stylopage ischnospora*. The gametangia became delimited basally by cross-walls (FIG. 2, *D, s*) at about the same time they were conjugating apically (FIG. 2, *D, u*); and soon thereafter the globose swelling in which the zygospore was to be formed began to develop in one of the gametangia—more usually in the one (FIG. 2, *D, d*) contributed from the mycelial hypha. Sexual reproductive apparatus contributed jointly from conidia and mycelial hyphae appeared, however, much less abundant than in *S. ischnospora;* most units here seeming to come from hyphae which either had not originated at all directly from a conidium, or, at least, were no longer recognizable as germ-tubes. In contrast to conidial chains, which usually ascended from promiscuously scattered positions, sexual apparatus was produced very largely in immediate proximity to a disintegrating animal. Prolongations or ramifications of the several widened hyphal elements (FIG. 2, *C, a–d;* FIG. 3, *J, a–e*) would put forth branches that soon became paired. After deposition of cross-walls in the branches (FIG. 2, *C, s;* FIG. 3, *J, s*) and apical fusion (FIG. 2, *C, u;* FIG. 3, *J, u*) of the gametangia thus delimited, a globose swelling or zygosporangium (FIG. 2, *C, f, g;* FIG. 3, *J, f–i*) would begin to form in one of the conjugating cells, usually at a distance between 5 and 10 μ from the place of union. Most frequently the two gametangia in a pair would be contributed from separate adhesive hyphae; such diclinism being very common immediately around disintegrating animals where sexual branches were generally present in greater abundance than some distance away. Yet propinquity of two congenial hyphae did not always insure a diclinous origin of sexual apparatus; for in some instances a mycelial hypha (FIG. 2, *E, a*) was found collaborating with another (FIG. 2, *E, b*) to produce a diclinous zygosporangium (FIG. 2, *E, c*) while less than 25 μ away it was forming a monoclinous zygosporangium (FIG. 2, *E, d*). If in some monoclinous reproductive units the two gametangia were borne terminally on separate branches arising close together from the same parent hypha (FIG. 2, *E, d*), in other monoclinous units the gametangia were represented by adjacent hyphal segments (FIG. 2, *F, a, b*) separated by an ordinary cross-wall (FIG. 2, *F, s*). Where the latter arrangement of parts occurred, each of the adjacent segments would put forth a short arching outgrowth. The two outgrowths, on meeting one another, united apically (FIG. 2, *F, u*) to form a bail-like conjugation-tube somewhat similar to the conjugation-tube in my *Acaulopage gomphoclada* (8: 278–283), but apparently never winding about the axial hypha. Following conjugation one of the gametangia would swell out locally into a globose excrescence (FIG. 2, *F, c*) that after attaining definitive size through accession of protoplasmic material contributed from both gametangia gave rise to a zygospore in much the same way as zygosporangia of more usual origin. In all sexual reproductive units alike the globose zygosporangial envelope later was found collapsed loosely about the boldly undulating zygospore wall, which, as in my *Acaulopage marantica* (5: 143–149), had the appearance of being separated from the spherical protoplast contained within it (FIG. 2, *G–R*). This protoplast at first seemed to be of uniformly granular texture (FIG. 2, *G, H*), though later it showed often two (FIG. 2, *I, J*) or three homogeneous reserve globules, and at full maturity it appeared to have the internal organization most usual in oöspores—the granular material being collected in a peripheral layer surrounding a single reserve globule and a smaller refringent body (FIG. 2, *K–R*).

The fungus is described under a specific name having reference to the frequently extraordinary width of the germ-tubes produced by its conidia.

Zoöpage pachyblasta sp. nov.

Mycelium effusum; hyphis filiformibus, incoloratis, primum continuis, parce ramosis, plerumque 1–2.4 μ (vulgo circa 1.7 μ) crassis, ad animalia minuta inhaerentibus, tum in partibus haerentibus saepius usque 4 μ latescentibus et ibi haustoria intus evolventibus quae protoplasma exhauriunt; haustorio ex pediculo 1–4 μ longo, 0.5–1 μ crasso et 2–4 ramulis assumentibus divaricatis 2.5–9 μ longis, 2–3 μ latis constante. Conidia incolorata, plerumque simplicia, interdum furcata, in catenulas ascendentes longas simplices vel ramosas digesta, prope basim catenulae saepius filiformia, levia, 30–50 μ longa, circa 1.7 μ crassa, in apice catenulae interdum clavata, in partibus catenulae intermediis plerumque elongato-fusiformia, utrimque acutula, distincte verrucosa, plerumque 15–30 μ longa, 1.6–2.3 μ crassa; hypha germinationis saepe circa 1.5 μ crassa, sed ubicumque in animali adhaerente vulgo 3–4 μ crassa. Gametangia plerumque 10–25 μ longa, ambo interdum ex cellulis unae hyphae intercalaribus contiguis constantia denique tubulo curvato conjungentia, sed saepius ambo in cellulis terminalibus constantia, nunc in duabus ramulis unae hyphae nunc in duabus ramulis aliarum hypharum oriunda, nunc alterum in tubo germinationis alterum in ramulo mycelii ortum, quandocumque terminalia apice conjungentia. Zygosporangium circa 5 μ sub junctura oriundum, plerumque 9–12.5 μ in diametro, primo leve, in maturitate membrana circum zygosporam laxe collapsa; zygospora flavida, globosa, valde verrucosa, 8.5–12 μ in diametro, membrana undulata ejus cellulam viventem sphaeralem 5.7–8 μ crassam laxe circumdante.

Amoebas 25–50 μ latas capiens consumensque habitat in foliis caulibusque *Solani tuberosi* putrescentibus prope Greeley, Colorado.

Mycelium spreading; vegetative hyphae filamentous, colorless, sparingly branched, at first continuous, mostly 1 to 2.4 μ (average about 1.7 μ) wide, adhering to minute animals, in the adhering portions often widening to 4 μ and from these portions intruding haustoria to appropriate the protoplasmic contents; haustorium consisting of a pedicel, 1 to 4 μ long and 0.5 to 1 μ wide, together with 2 to 4 assimilative branches 2.5 to 9 μ long and 2 to 3 μ wide. Conidia colorless, mostly simple, sometimes branched, arranged in long, simple or branched, ascending chains—those at the base of a chain often filamentous, smooth, 30 to 50 μ long, and about 1.7 μ wide, the one at the end of a chain sometimes clavate, those in intermediate portions of a chain mostly elongate fusiform, somewhat pointed at both ends, distinctly verrucose, mostly 15 to 30 μ long and 1.6 to 2.3 μ wide; the germ hypha often about 1.5 μ wide, but on the adhering animal commonly enlarging to a width of 3 to 4 μ. Gametangia mostly 10 to 25 μ long, both of a pair sometimes consisting of contiguous intercalary hyphal segments, and then conjugating through production of curved branches and through the union of these branches into an arcuate lateral connection; but both gametangia more often consisting of terminal hyphal segments borne on branches arising either from the same hypha or from different hyphae, and then, as also when occasionally one is supplied from a mycelial hypha while the other is supplied from a germinating conidium, conjugating apically. Zygosporangium usually formed about 5 μ from place of union, commonly 9 to 12.5 μ in diameter, at first smooth, its envelope at maturity collapsing loosely about the zygospore; zygospore yellowish, subspherical, boldly verrucose, 8.5 to 12 μ in diameter, its undulating wall at maturity loosely enveloping a globose living protoplast 5.7 to 8 μ in diameter.

Capturing and consuming an *Amoeba* usually 25 to 50 μ wide it occurs in decaying leaves and stems of *Solanum tuberosum* near Greeley, Colorado.

A DENDRYPHIUM-LIKE ZOÖPAGE THAT PREYS ON A TESTACEOUS RHIZOPOD

Several maizemeal-agar plate cultures which after being permeated with mycelium of *Pythium ultimum* Trow had been further planted with small quantities of partly decayed barley (*Hordeum vulgare* L.) straw gathered near Greeley, Colorado, early in October, 1945, showed after sixteen days in areas bordering the superadded material some sparse development of a catenulate fungus that in its gross appearance recalled the hyphomycetous genera *Dendryphium* and *Helminthosporium*. The same catenulate fungus subsequently came to light also in a culture of *P. ultimum* to which had been added a few pinches of friable detritus from partly decayed potato vines likewise collected near Greeley, Colorado, in October, 1945. Its sparse mycelium in all instances consisted of hyphae about 1.7 μ wide that gave off branches here and there, each of which entered the aperture of a testaceous rhizopod to terminate near the fundus of the animal in a simple and often somewhat irregular coil (FIG. 4, *A, a, b; B, a, b; C, a–c.* FIG. 5, *A–D; E, a–d*). Specimens of the rhizopod thus invaded were of somewhat compressed ovoid shape. Their testae, composed of

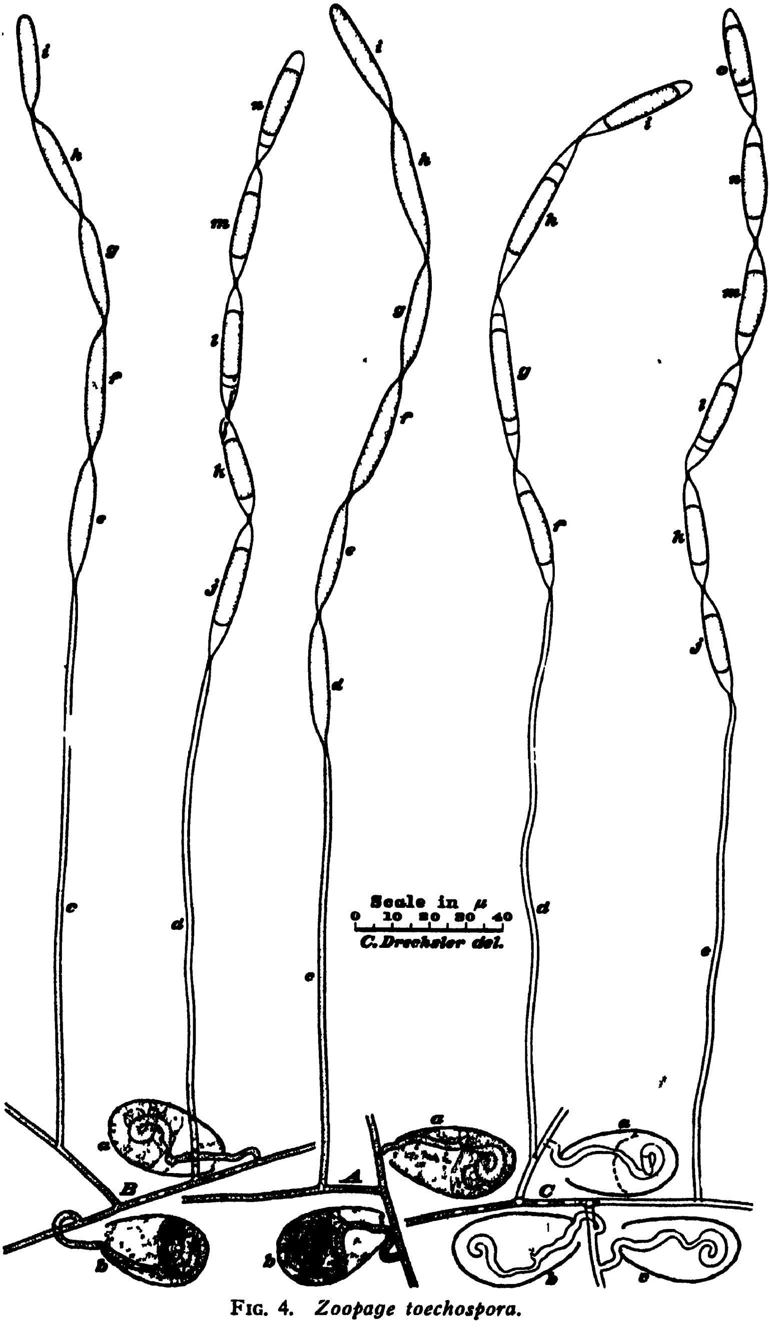

FIG. 4. *Zoopage toechospora.*

obscurely imbricated scales, measured commonly 28 to 38 μ in length, 19 to 21 μ in breadth, and about 15 μ in thickness. The aperture usually measured about 7 μ in width. The single spherical nucleus (FIG. 4, *A, a, b; B, a, b.* FIG. 5, *A–C*) varied in diameter from 6.2 to 8.2 μ, and contained a globose endosome 2 to 2.8 μ in diameter. In many invaded animals the relatively thick outer layer of nucleoplasm showed a slightly alveolar or faintly granular structure (FIG. 5, *A–C*), and thereby offered an appreciably darker appearance than the endosome. It seems possible that in these instances the nucleus may have been revealing harmful modifications induced by the presence of the fungus. The morphological features shown by animals in normal condition corresponded well to those ascribed to *Euglypha laevis* (Ehrenb.) Perty in the taxonomic treatises of Penard (**11**: 512–513) and of Wailes (**12**: 32–34). The protozoan species here concerned seemed identical, at all events, with the species that under the binomial *E. laevis* was earlier set forth as being parasitized by my *Cochlonema pumilum* (**6**: 398–402; **9**: 9–14).

Since the invaded animals were found distributed over the surface of the agar cultures not in a haphazard manner but in recognizably linear arrangement along the rather straightforward mycelial filaments, it was evident that they had been arrested in their locomotion because of encounter with the fungus. Yet the locomotion of the animals could not have been halted immediately at the moment of encounter, for sometimes the aperture of a captive was found as much as 25 or 35 μ from the origin of the invading branch (FIG. 5, *E, b, d*)—a distance seemingly greater than the length of any pseudopodium broad enough to offer much likelihood of secure adhesion. Even in instances where the rhizopod was found with its aperture close to a long mycelial filament, the invading branch often pursued an irregular roundabout course for 10 to 20 μ before entering the aperture. In profile view the branch entering the aperture was often seen passing over the thickened projecting tip of one of the marginal scales, or between the projecting tips of two adjacent marginal scales (FIG. 4, *A, a, b; B, a, b; C, a–c.* FIG. 5, *A; C; D; E, a, c, d*), in either case making intimate contact with the testa. Where the positional relationships were not shown in profile view (FIG. 5, *B; E, b*) it often seemed fairly cer-

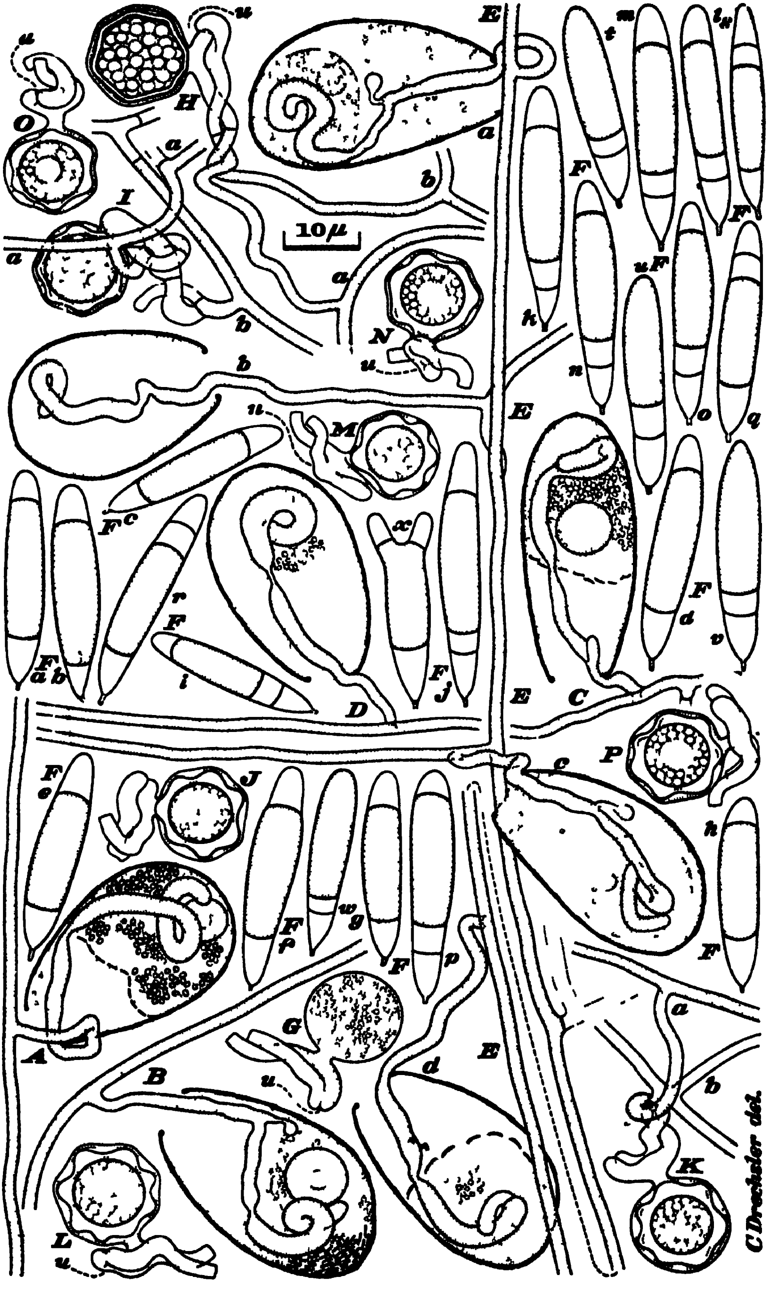

FIG. 5. *Zoopage toechospora.*

tain, nevertheless, that the invading branch touched one or two of the marginal scales oriented flatwise to the observer. Although the invading branch may have been put forth promptly when a pseudopodium of the moving animal touched the mycelial filament, locomotion may not have halted—that is, capture may not have been effected—until the branch had reached the aperture and through adhesion had fastened upon one or two of the projecting serrulated scales. If, as seems likely, capture was effected mainly through adhesion to the testa rather than to the protoplast, the animal in many instances could reasonably be presumed to have moved some distance away before the tip of the elongating branch found a suitable holdfast; the growth made by the fungus in pursuit of the slow fugitive thus probably accounting for the frequently considerable length of the hyphal part to which the captive eventually came to be tethered.

In its course through the forward portion of the animal's interior the invading branch sometimes maintained approximately the same width (FIG. 5, *B*; *C*; *E*, *b*) it showed externally, although at other times it widened noticeably (FIG. 5, *A*; *D*; *E*, *a*, *d*). About midway toward the fundus it nearly always revealed a rather pronounced constriction which evidently marked the place where it had made its way through a barrier laid down by the animal seemingly in an attempt to prevent the fungus from reaching the deeper protoplasm and the nucleus. Often the barrier consisted principally of small platelets, that manifestly represented scales in early stages of development (FIG. 5, *A*; *C*; *E*, *d*); the siliceous parts normally destined to make up the testa of a new individual being used prematurely in an unsuccessful effort to protect the prospective parent from destruction. Yet in some instances where the animal contained unmistakably a supply of small scales (FIG. 5, *B*) it did not divert them to a defensive use, but, instead, like the animals that contained no scales in process of formation (FIG. 5, *D*; *E*, *a–c*), formed a much less distinctly visible barrier from a transparent substance similar to the substance normally composing cyst envelopes in the species. Some little distance above the constriction the invading hyphal branch frequently showed a rather abrupt bend, which in many instances was further distinguished by the presence of a small, saccate, narrowly attached appendage (FIG. 5, *B*; *E*, *a*)—the curious arrangement thus presented probably having originated in an earlier and unsuccessful attempt at penetrating the animal's barrier. Beyond the constriction at the barrier the invading branch was prolonged often at the greatest width—from 3 to 4 μ—it attained anywhere (FIG. 5, *A; B; D; E, d*), though often, again, its width here—from 2 to 3 μ—did not markedly exceed its width in the anterior portion of the animal (FIG. 5, *C; E, a–c*). The terminal portion of the branch, as has been mentioned, was consistently coiled in noticeable measure, generally describing a single spiral or helicoid turn either in close proximity to the animal's nucleus (FIG. 5, *A, B*) or, less often, some distance away (FIG. 5, *C*). The terminally coiled hyphal branch, exclusive naturally of the part outside the testa, functioned as a haustorium in gradually depleting the animal of all protoplasmic materials (FIG. 5, *D; E, a–d*) until nothing remained but the empty shell; whereupon its own contents were withdrawn into the parent hypha (FIG. 4, *C, a–c*). While in its terminal coiling it offered some resemblance to the more elaborate assimilative apparatus of *Zoöpage thamnospira,* its virtually unbranched condition—the saccate appendage sometimes present and an occasional spur given off near the animal's mouth (FIG. 5, *C*) provided only a very meager display of ramification—makes the invading hyphal element conspicuous among haustoria of the Zoöpagaceae for simplicity of design. Indeed, with respect to simplicity it is probably surpassed in the family only by the outwardly undifferentiated assimilative branch of my *Acaulopage crobylospora* (10).

Thus amply nourished through the destruction of numerous captives the fungus reproduced asexually in some abundance. Prostrate mycelial hyphae gave rise here and there to erect filamentous branches (FIG. 4, *A, c; B, c, d; C, d, e.* FIG. 6, *A, a; B, a*) about 1.7 μ wide, which after attaining a height of 100 to 225 μ modified their further elongation through pronounced and rather evenly spaced fluctuations in width, thereby bringing into being a series of elongated ellipsoidal distended parts (FIG. 4, *A, d–i; B, e–i.* FIG. 6, *A, b–e; B, b–e*) connected by narrow isthmuses. When newly formed the distended parts, which commonly varied in number from four to six, usually measured from 25 to 40 μ in length and from 4.8 to 6 μ in width, whereas the isthmuses measured from 2 to

4 μ in length and 0.8 to 1 μ in width. From a consideration of conidial dimensions it seems probable that here as in most other catenulate Zoöpagaceae the distended parts subsequently increased appreciably in size through continued accession of protoplasmic material from the mycelium below. Although the chain of distended parts was usually found somewhat crooked rather than straight, it appeared remarkable that the very narrow isthmuses could sustain their massive burden so nearly in an erect posture. Since the hyphal membrane evidently maintained about the same thickness at the isthmuses as at the distended parts, the lumina of the isthmuses by way of which all distended parts were supplied—the lowermost one provided no exception since the tip of the supporting stalk was always markedly narrowed—hardly exceeded 0.5 μ or 0.6 μ in width. Because of difficulties of observation accompanying a dimension so minute, it was not clearly ascertained whether separation of the distended parts into individual conidia was accomplished by formation of cross-walls in the isthmuses, or by deposition of small quantities of plugging material in the narrow lumina, or by mere disintegration of the protoplasm within the isthmuses, or perchance by withdrawal of protoplasm from the isthmuses, followed possibly by slight collapse of the empty tubular membrane. In the disjunction of a conidial chain the isthmuses usually separated near the middle, so that each moiety eventually protruded from the end of a detached conidium as a rather well demarcated hilum.

During the maturation preceding such disjunction the supporting conidiophore was emptied of contents (FIG. 4, *B, d; C, d, e.* FIG. 6, *C, a; D, a; E, a, b*) and, further, each conidium was in large part evacuated as its entire protoplasmic contents were gathered into a segment embracing about three-fifths of the original volume of the spore (FIG. 4, *B, j–n; C, f–o.* FIG. 6, *C, b; D, b*). Among detached conidia representing terminal members of chains, many showed the living segment interposed between an empty locule at the hilum-bearing proximal end and an empty locule at the smoothly rounded distal end (FIG. 5, *F, a–h*). Almost equally numerous were specimens showing two empty cells at the basal end and one at the distal end (FIG. 5, *F, i–p.* FIG. 6, *F*), whereas the reversed arrangement with one empty cell at the proximal end and two empty cells

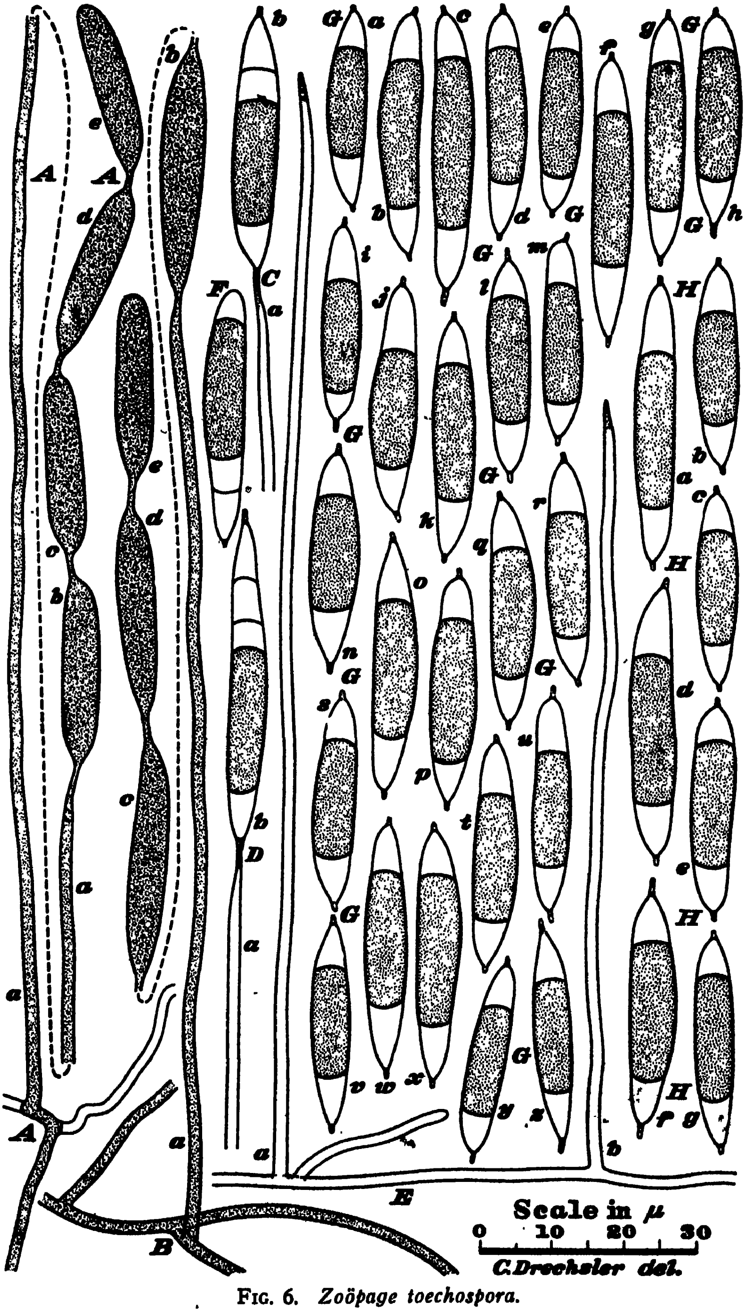

FIG. 6. *Zoöpage toechospora.*

at the distal end (FIG. 5, *F, q–s*) came under observation less frequently. Occasionally a terminal conidium was found filled with protoplasm clear to its rounded tip though furnished at the basal end with two empty locules (FIG. *F, t–w*); and somewhat rarely a bifurcate specimen of terminal origin bore an empty cell at the basal end as well as in each of the divergent arms (FIG. 5, *F, x*). A generally similar though slightly more varied distribution of empty locules prevailed among detached conidia that because of their development in intercalary or basal positions bore a protruding hilum at both ends, and therefore gave no reliable indication as to which of the ends was the proximal and which the distal one. Here likewise specimens with an empty cell at each end (FIG. 6, *G, a–z; H, a–g*) were most abundant, but almost equally numerous were specimens with a single empty cell at one end and two empty cells at the other end (FIG. 7, *A, a–z; B*). Some conidia of proximal or intercalary origin were furnished with four empty cells. The living segment in such spores appeared somewhat less often placed symmetrically between two empty segments at each end (FIG. 7, *C, a–c*) than disposed unsymmetrically between one empty segment at one end and three empty segments at the other end (FIG. 7 *D, a–f*). In some observed instances where the basal conidium remained attached to the supporting hypha after a cover-glass had been placed on the agar substratum, it was clearly evident that the spore bore a single empty cell at its proximal end and two (FIG. 6, *C, b*) or three (FIG. 6, *D, b*) empty cells at its distal end.

On and below the surface of the substratum the fungus gave rise sparingly to sexual reproductive apparatus of distinctive appearance (FIG. 5, *G–P*). In initiating development of a zygospore two zygophoric branches from separate mycelial filaments (FIG. 5, *H, a, b; I, a, b; K, a, b*) would become paired by winding distally about one another. In each branch a cross-wall would then be formed to delimit a terminal cell, or gametangium, usually 12 to 20 μ in length. Conjugation thereupon took place, in some instances being accomplished by the tip-to-tip fusion (FIG. 5, *L, u; N, u; O, u*) familiar in many related forms. Since, however, more often the rounded tips of the sexual cells were plainly not in contact with one another, conjugation perforce usually took place through lateral fusion. While the place of union in many instances of lateral conjugation could not be distinctly made out, it seemed sufficiently clear in other instances that communication between the laterally apposed cells was sometimes established immediately below the two tips (FIG. 5, *G, u*) and sometimes fully 5 μ backward (FIG. 5, *M*). From a position commonly 2 to 8 μ below its apex, one of the gametangia would then put forth a globose excrescence that enlarged as it received protoplasmic material from the sexual branches. Usually the globose body reached a diameter of 12 to 15 μ before the gametangia became empty. As a separate zygospore wall made its appearance within the subspherical envelope, the protoplast underwent change from a granular (FIG. 5, *G*) to a globuliferous (FIG. 5, *H*) consistency. Thereupon the zygospore wall, which at first presented a somewhat angular outline, assumed a rather boldly undulating contour while the protoplast began to contract into a spherical form (FIG. 5, *I–L*). On further maturation a rather large homogeneous globule usually made its appearance in the center of the protoplast. Although in some instances the peripheral layer ultimately came to consist largely of granular material (FIG. 5, *M*), most zygospores appeared to retain during their resting period a pronouncedly globuliferous consistency in their peripheral protoplasmic layer (FIG. 5, *N–P*).

In the height of the erect hyphal branches supporting its conidial chains, as well as in the relatively great width and size of its conidia, the fungus departs markedly from the morphological trend expressed in other species of *Zoöpage*, and would seem to reveal close kinship rather with the genus *Stylopage*. While obviously the plural septa contained in the conidium are formed as retaining walls to mark a final stage, and often also one or two intermediate stages in the evacuation of the proximal and distal ends, the elongate ellipsoidal shape of the spore, together with the number and position of its partitions, makes for a remarkable resemblance to various species of *Helminthosporium*. The multiple septation of the conidium, so unusual for a catenulate member of the Zoöpagaceae, and, indeed, so strongly divergent from the spore morphology prevalent in the Phycomycetes, suggests for the fungus a specific epithet compounded partly of a word meaning "wall."

Zoöpage toechospora sp. nov.

Mycelium effusum; hyphis filiformibus, incoloratis, primum continuis, parce ramosis, plerumque 1.2–2 μ crassis, ad animalia minuta inhaerentibus, ea impedientibus, in quodque captivum unicum ramum intrudentibus qui protoplasma exhaurit; ramo in totum 40–80 μ longo, parte extra animal (retinaculo) 3–35 μ longa, 1.2–2 μ crassa, parte interna assumenti (haustorio) 30–50 μ longa, 2–4 μ lata, in medio animalis saepe flecta et interdum appendice sacculiformi praedita et praeterhac nonnunquam plus minusve constricta, deinde propius fundum animalis in spiram semel convoluta. Hyphae conidiophorae incoloratae, erectae, plerumque 100–225 μ altae, 1.5–1.8 μ crassae, apice usque 1 μ attenuatae, ibi 4–6 conidia copulis 2–4 μ longis, 0.8–1 μ crassis in catenulam connexa ferentes; conidiis incoloratis, elongato-ellipsoideis vel aliquid fusiformibus, quandocunque in summa catenula oriundis sursum rotundatis et rarenter bifurcis sed quandocunque alibi ortis semper simplicibus et post disjunctionem utrimque in copulam ruptam acutule abeuntibus, plerumque rectis sed interdum parum curvatis, 24–54 μ longis, 4.4–7 μ latis, in unica cellula viventi 15–26 μ longa et 2–4 (plerumque 2 vel 3) cellulis vacuis 2–10 μ longis consistentibus, ita utroque extremo saepissime 1 vel 2 cellulis vacuis praeditis, rarenter uno extremo aut protoplasmatis repletis aut 3 cellulis vacuis praeditis. Rami zygosporiferi saepe 15–55 μ longi, ambo ex aliis hyphis mycelii oriundi, inter se vulgo aliquantulum circumplicantes, primum continui, postea uterque septo cellulam sexualem (gametangium) terminalem 12–20 μ longam, 1.5–3 μ crassam delimitans; ambabus cellulis prope apicem vel usque 5 μ sub apice conjunctis utravis 2–8 μ sub apice zygosporangium gignente; zygosporangio sphaerali, plerumque 12–15 μ in diametro, primum levi, in maturitate membrana ejus circum zygosporam laxe collapsa; zygospora paululum flavida, globosa, 11–13.5 μ in diametro, valde verrucosa, membrana undulata ejus cellulam viventem laxe circumdante; cellula viventi sphaerali, 8–9.5 μ crassa, multis globulis farcta.

Euglypham laevem capiens consumensque habitat in stramento (foliis acere caulibusque) *Hordei vulgaris* putrescenti et foliis caulibusque *Solani tuberosi* putrescentibus prope Greeley, Colorado.

Mycelium spreading; vegetative hyphae colorless, filamentous, sparingly branched, at first aseptate, mostly 1.2 to 2 μ wide, capturing minute animals through adhesion, then sending a branch into each captive to assimilate its protoplasmic contents; the invading branch often 40 to 80 μ in total length, consisting of a proximal external portion (tether) 3 to 35 μ long, together with a distal assimilative portion (haustorium), 30 to 50 μ long and 2 to 4 μ wide, which often is bent markedly near the middle of the animal where it sometimes bears a sac-like appendage besides being modified by a pronounced constriction, and which terminates beyond the constriction in a spiral coil of approximately one turn. Conidiophorous hyphae colorless, erect, mostly 100 to 225 μ high, 1.5 to 1.8 μ wide, narrowing to a width of about 1 μ at the apex whereon is borne a chain of 4 to 6 conidia held together by connections 2 to 4 μ long

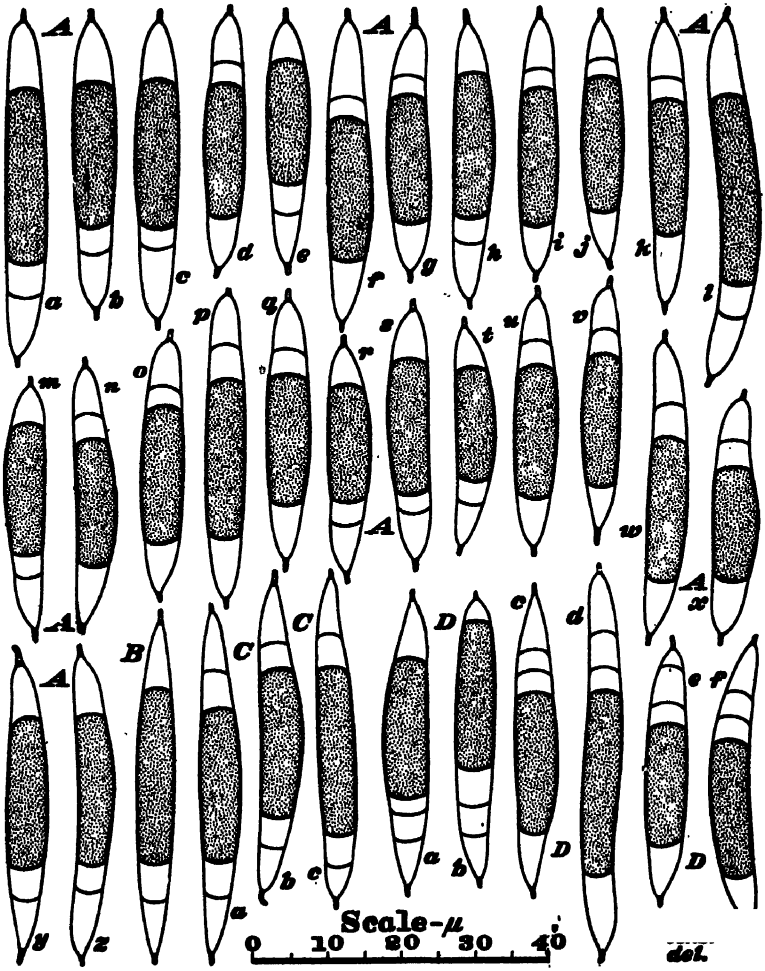

FIG. 7.

and 0.8 to 1 μ wide; conidia colorless, elongated ellipsoidal or somewhat spindle-shaped, always rounded at the tip when formed at the end of a chain and then occasionally forked, but when formed elsewhere in a chain always unbranched and after disarticulation terminating somewhat sharply at both ends in a projecting stump of the broken connection, in any case (whether formed terminally or lower down) mostly straight though sometimes slightly curved, mostly 24 to 54 μ long and 4.4 to 7 μ wide, consisting of one living segment 15 to 26 μ long, together with 2 to 4 (mostly 2 or 3) empty segments 2 to 10 μ long, and thus usually provided at each end with 1 or 2 empty segments, rarely being provided at one end with 3 empty segments or filled clear to one end with protoplasm. Zygophoric branches often 15 to 55 μ long, the two of a pair arising from separate hyphae, commonly winding about one another in some measure, at first aseptate, each later forming a cross-wall to delimit a terminal sexual cell (gametangium) commonly 12 to 20 μ long and 1.5 to 3 μ wide; after conjugation of the sexual cells at or immediately below their apices or backward from their apices as much as 5 μ, one of them giving rise 2 to 8 μ from its tip to a lateral zygosporangium; the zygosporangium subspherical, mostly 12 to 15 μ in diameter, at first smooth but at maturity its membrane collapsing loosely about the zygospore; zygospore somewhat yellowish, globose, 11 to 13.5 μ in diameter, boldly verrucose, its pronouncedly undulating membrane loosely surrounding a spherical living protoplast, 8 to 9.5 μ in diameter, which usually contains numerous globules.

Capturing and consuming *Euglypha laevis* it occurs in partly decayed straw (leaves, chaff, and stems) of *Hordeum vulgare* and in decaying leaves and stems of *Solanum tuberosum* near Greeley, Colorado.

DIVISION OF FRUIT AND VEGETABLE CROPS AND DISEASES,
PLANT INDUSTRY STATION,
BELTSVILLE, MARYLAND

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EXPLANATION OF FIGURES

FIG. 1. *Zoöpage virgispora;* drawn to a uniform magnification with the aid of a camera lucida; × 1000. *A,* Portion of mycelium with six captured amoebae; four of the animals, *a–d,* belong to a species distinguished by a nucleus with a single central body, whereas the two others, *e–f,* belong to a species having a nucleus with about twelve flattened ellipsoidal peripheral bodies. *B,* Portion of hypha with a captured specimen of the *Amoeba* whose nucleus contains a single central body. *C,* Portion of mycelium with two captured individuals, *a* and *b,* of the *Amoeba* whose nucleus contains about twelve peripheral bodies; the nucleus of one animal, *a,* appears normal, whereas that in the other, *b,* is abnormally elongated. *D,* Portion of hypha with two captured amoebae, *a* and *b;* one of the animals, *a,* shows an abnormally elongated nucleus in which about twelve somewhat degenerate peripheral bodies are visible; the other, *b,* represented by an almost completely empty pellicle, cannot be identified owing to disappearance of its nucleus. *E,* Portion of prostrate mycelial filament bearing a fertile hypha wherein five parts, *a–e,* destined for conversion into conidia, are shown connected by narrow isthmuses. *F,* Portion of prostrate mycelial filament bearing a fertile hypha wherein six expanded parts, *a–f,* destined for conversion into conidia, are shown connected by narrow isthmuses. *G,* Portion of mycelial filament shown still continuous with the branched basal member of a chain; all other members of the axial chain, as well as all members of the branch attached to the spur, have become detached. *H,* Portion of prostrate hypha with a sterigma whereon is attached a chain of five conidia, *a–e.* *J,* Portion of prostrate hypha with two sterigmata unusually close together; on them are shown attached two conidia, *a* and *b,* representing basal members of spore chains. *K, L,* Distal portions of two conidial chains, showing in each a subterminal conidium of ordinary length, *a,* and a relatively short terminal conidium, *b,* of somewhat clavate shape. *M,* Detached conidia, *a* and *b,* each with a lateral spur whereon was borne earlier a lateral branch of a conidial chain. *N* (*a–s*), *O* (*a–p*), Detached conidia, showing usual variations in size and shape.

FIG. 2. *Zoöpage pachyblasta;* drawn to a uniform magnification with the aid of a camera lucida; × 1000. *A,* Well-developed, normal specimen of *Amoeba* sp. habitually captured by the fungus; besides its nucleus, *n,* and its contractile vacuole, *v,* the animal contains numerous spores of an unidentified fungus. *B,* Specimen of *Amoeba* sp. into whose protoplasm four adhering conidia, *a–d,* have each intruded a haustorium in early stage of development; each conidium has also put forth a germ hypha; the germ hyphae extended from *c* and *d* have widened markedly in their proximal portions which are in contact with the animal; *n,* nucleus of animal, showing alveolar markings in the central body; *v,* contractile vacuole. *C,* Specimen of *Amoeba* sp. held captive through adhesion to several ramifying hyphae; only one ramifying system, which includes three adhering branches, *a–c,* is shown in contact with the animal, though two other ramifying systems are represented in the distal hyphal parts *d* and *e;* gametangia contributed from *a* and *b* have conjugated with gametangia from *d* and *e,* respectively, leading to development of the zygosporangia *f* and *g,* respectively; *s,* septa delimiting gametangia; *u,* place of union between gametangia. *D,* Unit of sexual reproductive apparatus contributed from a germinating conidium, *a,* and a mycelial filament, *b;* the former supplying the gametangium *c,* the latter the gametangium *d;* after apical conjugation of the gametangia a zygosporangium began developing in *d; s,* cross-walls proximally delimiting the paired gametangia; *u,* place of union between gametangia. *E,* Two mycelial hyphae, *a* and *b,* that together have contributed a pair of gametangia whose conjugation has resulted in the young zygosporangium *c;* the hypha *a* further has by itself given rise to the growing zygosporangium *d* by putting forth a pair of sexual branches from positions not far apart. *F,* Hypha with two adjacent intercalary gametangia, *a* and *b,* separated by the cross-wall *s;* after the conjugation tubes extended reciprocally from the gametangia had united at their apices, *u,* the zygosporangium *c* began growing out laterally from *b. G, H,* Zygosporangia, each containing an immature zygospore with its spherical protoplast still of granular texture throughout. *I, J,* Zygosporangia, each containing a nearly mature zygospore with two reserve globules in its protoplast. *K–R,* Mature zygospores, each loosely surrounded by the slightly collapsed zygosporangial envelope.

FIG. 3. *Zoopage pachyblasta;* drawn to a uniform magnification with the aid of a camera lucida; × 1000, except in *B. A,* Specimen of *Amoeba* sp. habitually taken by the fungus; two conidia, *a* and *b,* of the fungus are shown adhering to the animal, which contains the nucleus *n* and the contractile vacuole *v. B,* Scant arachnoid aerial weft composed of branched ascending conidial chains originating from assimilative hyphae affixed to the three animals *a–c;* × 100. *C,* Proximal portion of aerial hypha, showing above the filamentous part *a* two filamentous conidia, *b* and *c,* representing proximal members of a chain. *D,* Branching aerial hypha still continuous with the part *a,* which while awaiting delimitation as a conidium is supporting two conidial chains that are represented by only the proximal spores *b–k;* one of the chains is branched at the conidium *g,* which accordingly bears a lateral spur. *E,* Intercalary portion of branched chain, showing five conidia, *a–e;* the conidium *b* at the crotch bears a lateral spur. *F,* Intercalary portion of a branched chain, showing six conidia, *a–f;* the conidium *a* at the

crotch bears a lateral spur. *G,* Intercalary portion of branched chain, showing seven conidia, *a–g;* the conidium *b* at the crotch bears a lateral spur near its proximal end, whereas its distal end is bent sideways to form an oblique terminal spur. *H,* Intercalary portion of conidial chain, showing three conidia, *a–c,* in straight alignment. *I,* Detached conidia, *a–s,* showing usual variations in size and shape. *J,* Four widened predaceous hyphae, *a–d,* among untidy remnants of granular protoplasm left scattered about after destruction of a captured *Amoeba; e,* prolongation from a fifth predaceous hypha whose widened part is not shown; *f–i,* young zygosporangia resulting from conjugation of gametangia supplied from the five predaceous hyphae—*f* being traceable backward to *a* and *b, g* being traceable to *c* and *d, h* being traceable to *b* and *d, i* being traceable to *b* and *e; s,* cross-walls proximally delimiting paired gametangia; *u,* place of union between paired gametangia.

FIG. 4. *Zoöpage toechospora;* drawn to a uniform magnification with the aid of a camera lucida; × 500 throughout. *A,* Portion of mycelium with two captured specimens of *Euglypha laevis, a* and *b,* each invaded by an assimilative branch; *c,* young erect conidiophore still continuous distally with a series of six young conidia, *d–i.* *B,* Portion of mycelium with two captured specimens of *E. laevis, a* and *b,* each of them invaded by an assimilative branch; *c, d,* two erect conidiophores, one of them (*c*) still filled with protoplasm and still continuous distally with the series of five young conidia, *e–i,* the other (*d*) almost completely empty and bearing a chain of five mature conidia, *j–n.* *C,* Portion of mycelium with three captured specimens of *E. laevis, a–c,* each completely expropriated of contents by an assimilative branch from which the protoplasm has been withdrawn; *d, e,* two empty erect conidiophores, one of them (*d*) bearing a chain of four mature conidia, *f–i,* and the other (*e*) bearing a chain of six mature conidia, *j–o.*

FIG. 5. *Zoöpage toechospora;* drawn to a uniform magnification with the aid of a camera lucida; × 1000 throughout. *A, B,* Portions of prostrate hyphae from each of which an assimilative branch has grown into a captured living specimen of *Euglypha laevis* lying flatwise on the substratum. *C,* Portion of prostrate hypha from which an assimilative branch has grown into a captured living specimen of *E. laevis* resting edgewise on the substratum. *D,* Portion of prostrate hypha from which an assimilative branch has grown into a captured specimen of *E. laevis* lying flatwise on the substratum; the animal seeming near death from loss of protoplasm. *E,* Portion of mycelium from which a separate assimilative branch has grown into each of four captured specimens of *E. laevis, a–d,* lying flatwise on the substratum; apparently all four animals have succumbed to death from loss of protoplasm; in *d* withdrawal of contents from the assimilative branch has begun. (Owing to lack of space the main mycelial hypha here is shown in parts, with contiguous ends connected by a broken line.) *F,* Detached conidia, *a–x,* each of which was formed as the terminal member of a chain: *a–h,* individuals with an empty segment at both ends; *i–p,* individuals with two empty segments at the proximal end, and one empty segment at the distal end; *q–s,* individuals with one empty segment at the proximal end, and two empty segments at the distal end; *t–w,* individuals with two empty segments at the proximal end, but distally remaining filled with protoplasm clear to the tip; *x,* distally bifurcate individual with a large empty segment at the proximal

end, and a small empty segment in each of the two divergent arms. *G,* Young unit of sexual reproductive apparatus, showing a nearly full-grown zygosporangium borne on a gametangium that near its tip, *u,* is fused laterally with its mate. *H,* Unit of sexual reproductive apparatus showing origin of paired gametangia from two separate hyphae, *a* and *b;* the wall of the young zygospore is clearly separated from the zygosporangial membrane surrounding it, and is taking on a more undulating contour; the protoplast still fills the zygospore completely, and appears of globuliferous character throughout *I–L,* Units of sexual apparatus wherein the zygosporangial membrane is collapsing about the undulating zygospore wall that loosely envelops a spherical protoplast of globuliferous appearance throughout; in *I* and *K* the origin of the paired gametangia from two separate hyphae is shown. *M,* Nearly mature unit of sexual reproductive apparatus in which the spherical protoplast within the boldly undulating zygospore wall shows a central homogeneous region that is surrounded by globules in smaller number than usual; the place of union, *u,* between the gametangia here appears to be farther from the tip than usual. *N–P,* Mature units of sexual reproductive apparatus, in each of which the undulating zygospore wall within the somewhat collapsed zygosporangial membrane envelops loosely a spherical protoplast that shows a homogeneous central globule surrounded by a globuliferous protoplasmic layer. (*u,* Place of union between paired gametangia.)

Fig. 6. *Zoöpage toechospora;* drawn to a uniform magnification with the aid of a camera lucida; × 1000 throughout. *A, B,* Portions of mycelium, each bearing an erect young conidiophore, *a,* that is still continuous distally with a series of four young conidia, *b–e.* (Owing to lack of space each continuous erect element is shown in two parts, with contiguous ends connected by a broken line.) *C,* Distal portion of empty mature conidiophore, *a,* showing attachment of a conidium, *b,* representing the lowermost member of a chain. *D,* Distal portion of empty mature conidiophore, *a,* to which is attached the conidium *b,* the lowermost member of a chain. *E,* Portion of empty prostrate hypha bearing two conidiophores, *a* and *b,* from which all protoplasmic contents have been withdrawn and from which all conidia have become detached. *F,* Detached conidium representing the terminal member of a chain. *G* (*a–z*), *H* (*a–g*), Detached conidia representing proximal and intercalary members of chains; all showing a single empty segment at each end.

Fig. 7. Detached conidia of *Zoöpage toechospora* formed as proximal or as intercalary members of chains, and furnished with three or four empty segments; all drawn to a uniform magnification with the aid of a camera lucida; × 1000. *A* (*a–x*), *B,* Specimens showing one empty segment at one end, and two empty segments at the other end. *C,* Detached conidia, *a–c,* each showing two empty segments at each end. *D,* Detached conidia, *a–f,* each showing one empty segment at one end, and three empty segments at the other end.

CYTOLOGY OF THE TELIOSPORES, BASIDIA, AND BASIDIOSPORES OF *SPHENOSPORA KEVORKIANII* LINDER

LINDSAY S. OLIVE

(WITH 4 FIGURES)

INTRODUCTION

The genus *Sphenospora* was founded by Dietel (1897), who designated *Diorchidium pallidum* Wint. as the type species. Since then probably only four authentic new species have been described, the most recent of which is *S. kevorkianii* Linder (1944). *Sphenospora* is a tropical genus, having been reported in Africa as well as South and Central America.

The rusts of this genus possess subepidermal uredinia and telia, and at times, according to some reports, subepidermal pycnia, all on one host. No aecia and no alternate hosts, if such exist, have been reported for any of its species. The group is particularly characterized by its thin-walled, two-celled, vertically septate teliospores, which germinate upon reaching mature size. Three species have been described on monocots. These are *S. pallida* (Wint.) Dietel, *S. yurimaguasensis* (P. Henn.) Jackson, and *S. kevorkianii* Linder. One species, *S. copaiferae* (P. Henn.) Syd., is parasitic on the legume *Copaifera*. Another species, *S. berberidis* Lagerh., has been described on barberry in Ecuador.

Linder (1944) has adequately described the morphology of *S. kevorkianii*. His paper includes accurate illustrations of the rust, particularly of the telial elements. This species is distinguished from all others in the genus by the presence of paraphyses in the telial sorus and in its parasitism of an orchid (*Epidendrum*).

MATERIALS AND METHODS

The material used in the present investigations was very kindly forwarded to me by Dr. Linder, who in turn had received it from Mr. Lewis Long in Nicaragua. The collection consisted of diseased leaves of *Epidendrum* preserved in formalin-acetic-alcohol solution. The telia were found in various stages of development, the majority containing germinating teliospores. Since the uredinia were old and had finished sporulating, no attempt has been made to study them other than to determine that the urediospores are binucleate.

Some of the material was imbedded in paraffin and sectioned at 7–10 μ. Two methods of staining were used, one being the iron alum haematoxylin technique and the other based on the crystal violet-iodine procedure outlined by Sass (Elements of Botanical Microtechnique, pp. 76–77. McGraw-Hill. **1940**). Orange gold was used as a counter stain in the latter technique and proved particularly useful in bringing out the thin walls of the teliospores and basidia. Each technique had some advantage over the other, and both were needed to give adequate preparations for cytological study.

INVESTIGATIONS

From the standpoint of illustrating and describing all the important stages in nuclear division during the development of the telium, the present work is inadequate. Clear mitotic figures are rare. This is possibly attributable to the condition of the material at the time it was preserved, or to the killing fluid used. It is particularly noticeable that, during phases of nuclear fusion or division, the cytoplasm very frequently absorbs a great deal of the stain, which is almost impossible to remove by destaining. However, enough information has been obtained to follow with reasonable accuracy the cytological development beginning with the production of the teliospore initials and ending with basidiospore formation.

It should be noted here that an examination of the diseased host tissues has revealed the presence of both uninucleate and binucleate haustoria in the cells. The uninucleate ones seemed to be more abundant in the material which I examined.

The telium begins as a palisade of binucleate hyphal tips which aggregate in groups beneath the epidermis. Conjugate nuclear divisions occur in these cells, which may be termed the basal cells, denoting their position in the mature telium (FIG. 1, *1, 2*). Only late anaphase or telophase spindles were observed here and the chromosomes could not be distinguished. The cell produced by a basal cell during this division develops into a teliospore or a pa-

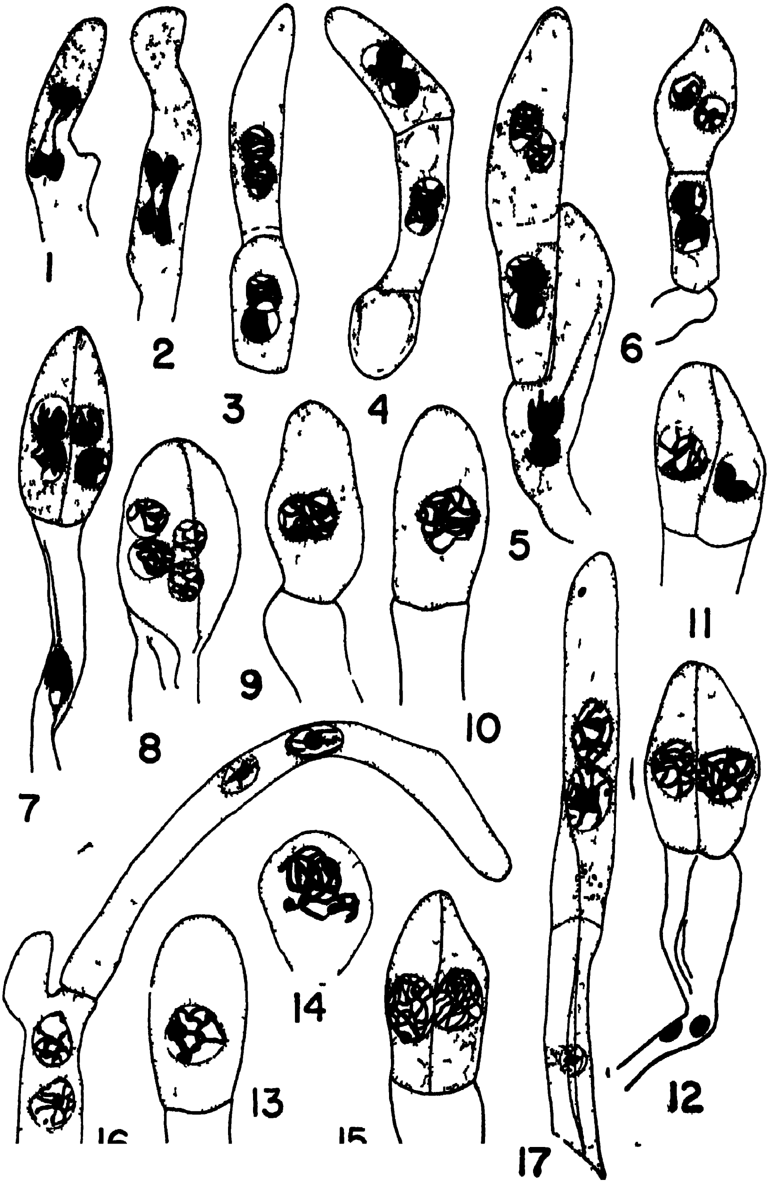

FIG 1 *Sphenospora kevorkianii.*

raphysis (FIG. 1, *3*). It may therefore be considered a paraphysis initial or a teliospore initial. The two are at first indistinguishable. Other initials may bud out from the same basal cell (FIG. 1, *5, 16*). One basal cell may produce several teliospores and paraphyses, or sometimes only a group of paraphyses. The initial may remain unicellular and develop directly into a one-celled, binucleate paraphysis (FIG. 1, *16; 2, 1, 2*), or less frequently another division may occur to produce a two-celled paraphysis (FIG. 1, *17*). The nuclei in these paraphyses may generally be found to contain distinct nucleoli and radiating bands of chromatin (FIG. 2, *1, 2*).

Many of the initials, probably averaging not over one-half of those produced in a telium, are teliospore initials. Each binucleate teliospore initial divides, evidently with an accompanying conjugate nuclear division, to produce the young teliospore (FIG. 1, *4, 6*). The apical cell becomes the spore proper, whereas the cell beneath it becomes the stalk. Some of the two-celled figures at first cannot be distinguished as paraphyses or teliospores (FIG. 1, *5*).

The apical cell of the young teliospore now undergoes a single division. The two nuclei apparently divide conjugately and their spindles are at right angles to the long axis of the spore, judging from the position of the nuclear pairs following the division (FIG. 1, *7, 8;* 4, *A*). As a result the cross wall is laid down vertically as the apical cell is divided into a two-celled spore. Actual nuclear divisions during this development were rare in the material studied, and the nuclei were generally observed in leptotene, with distinct chromatin bands winding about in the clear interior of nuclear sap. Nucleoli may be frequently observed in these nuclei (FIG. 1, *7, 8*).

Very soon after the two cells are produced the two nuclei in each cell come together and karyogamy takes place (FIG. 1, *9–15*). At this time the chromatin may be in the form of particularly well-defined sinuous bands (FIG. 1, *9, 10, 12*), or sometimes the chromatin strands may clump together during the fusion, so that they are indistinguishable (FIG. 1, *11*). After karyogamy has occurred, paired areas may occasionally be observed along some of the chromatin strands (FIG. 1, *14*). These strands eventually become finer in appearance in the fully developed fusion nucleus, which is now almost the same diameter as the cell it occupies (FIG. 1, *15;* 4, *B*). Each fusion nucleus contains a single nucleolus.

During this development the pedicel of the teliospore elongates considerably, remaining broad above but tapering below. Its cytoplasmic contents disappear and its two nuclei become small and dense, or degenerate completely (FIG. 1, *7, 12*). The mature stalks appear hyaline.

The entire development of the teliospore is similar to that described for *Puccinia,* except that in *Sphenospora* a vertical rather than horizontal cross wall is laid down in the teliospore and the spore wall remains thin. Eventually the maturing paraphyses and teliospores create sufficient pressure upon the overlying epidermis to rupture it; after which the telial elements are exposed and the basidia are produced (FIG. 4, *H, I*).

Shortly after karyogamy has been completed in the teliospore, each of the two cells may germinate apically to produce a basidium. The nucleus and cytoplasm in each cell pass up into the developing basidium. The nucleus is now smaller than it was in the teliospore, but the sinuous chromatin strands are still distinct, as the nucleus remains in leptotene (FIG. 2, *3, 4*). The two basidia generally develop at about the same rate and lie side by side throughout their development. A cross wall may appear at the base of the basidium, or it may fail to appear and then the lower cell of the basidium remains continuous with the teliospore cell. This is indicated in many of the illustrations.

During prophase of the first, presumably meiotic, division of the diploid nucleus in the young basidium, the nucleolus seems to be discharged into the cytoplasm (FIG. 2, *5, 6*). Occasionally two nucleolus-like bodies may be observed in the cytoplasm (FIG. 2, *7, 10*). This may mean that in such cases the two nucleoli of the nuclear pair in the teliospore cell both persisted separately during karyogamy. However, there is no conclusive evidence for this hypothesis. During late prophase the nuclear membrane disappears (FIG. 2, *7*).

A few spindles with chromosomes were observed during the first division (FIG. 2, *8*). In late anaphase and in telophase the chromosomes are indistinguishably clumped together in two dense masses, while the spindle fibers coalesce into one or two dense strands between the two masses (FIG. 2, *9*). The chromatin in each newly formed nucleus generally returns to the leptotene phase with the characteristic sinuous chromatin strands. In at least a number of cases a nuclear membrane appears around the new nuclei (FIG. 2, *10, 11*). A cross wall may or may not be laid down following this first nuclear division; more frequently it does not appear before the second meiotic division has been completed (FIG. 2, *12–20*).

During the second division, the two nuclei in a basidium generally do not divide quite simultaneously. Again spindles with chromosomes appear and the chromosomes clump together at opposite poles in the later stages of division just as they did in the first division (FIG. 2, *13–17*). The resulting four nuclei are at first dense in appearance and stain darkly throughout (FIG. 2, *18, 20*), but eventually they return to the leptotene condition with distinct chromatin strands and nuclear membranes (FIG. 2, *19*). In neither of the two meiotic divisions was it possible to count the number of chromosomes present.

Typically the first cross wall appears in the quadrinucleate basidium, dividing it into two cells, one uninucleate and the other trinucleate (FIG. 2, *19, 20*). A second wall then appears and divides the trinucleate cell into a binucleate cell and an uninucleate cell, the binucleate cell generally being in the center of the basidium (FIG. 2, *21*; 3, *1a, 2b*; 4, *C*). Occasionally nucleoli are observed in these nuclei (FIG. 2, *21*; 3, *18*). Ordinarily no further cell divisions occur and the basidium germinates directly to produce three basidiospores.

Each cell of the basidium gives rise to a sterigma which enlarges at its tip to produce a single basidiospore. The length of the sterigma is variable, and this is probably correlated with the distance the sterigma must grow in order to expose its tip. The cytoplasm and nucleus in each of the uninucleate cells pass up into the developing basidiospore (FIG. 3, *16*). In the case of the binucleate cell, the cytoplasm and both nuclei pass into the basidiospore (FIG. 3, *13–15, 17*). When a nucleus passes from a basidial cell into the developing basidiospore, it becomes very much attenuated in the region of the sterigma (FIG. 3, *17*; 4, *D*). The migrating nucleus shown in the illustrations revealed three separate strands of chromatin, only two of which could be shown at once, passing through the sterigma.

There is apparently no division of the nuclei in the basidiospores.

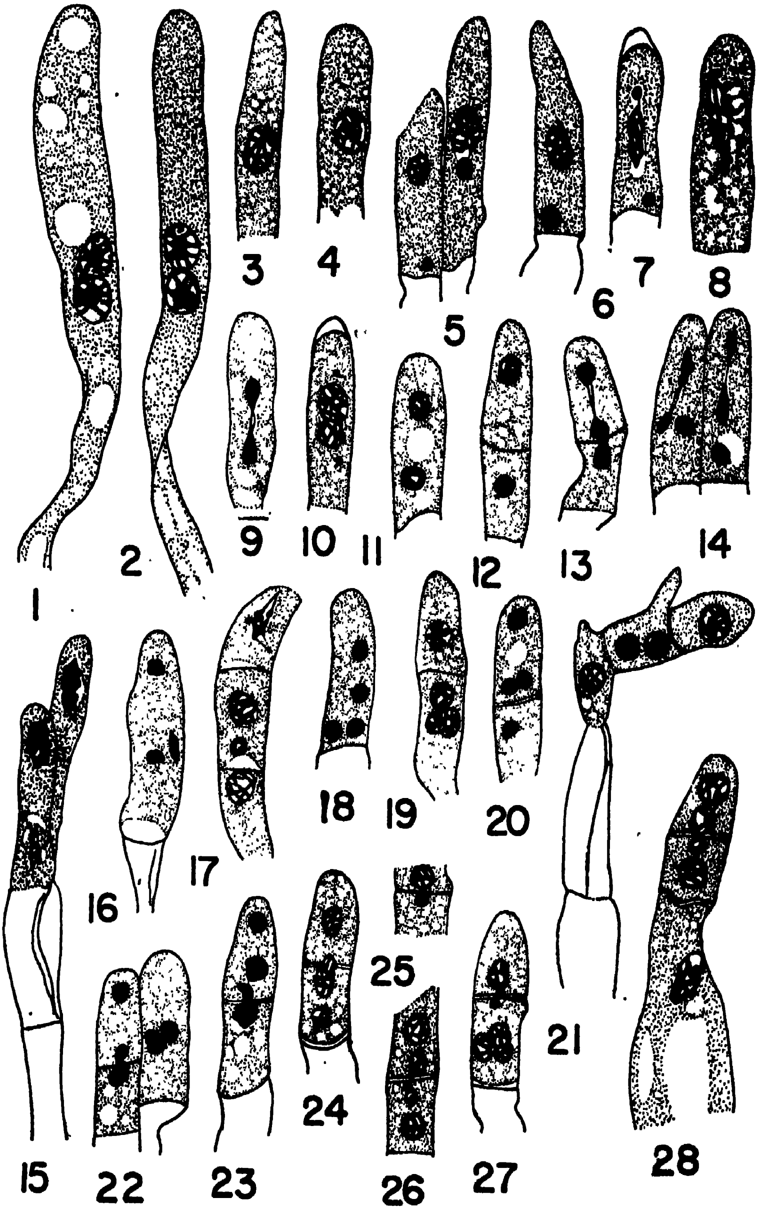

FIG. 2. *Sphenospora kevorkianii.*

The uninucleate spores appear to remain in that condition after they are shed, whereas both nuclei persist in the binucleate spore (FIG. 3, *20*). The uninucleate basidiospores are far more abundant than the binucleate ones. After the nuclei have entered into the basidiospores they return to the leptotene condition, and occasionally a nucleolus may be observed (FIG. 3, *20b*). I have not found any of the basidiospores germinating.

As a result of the absence of any strict correlation between nuclear division and septation in the basidium, several interesting irregularities were observed during the development of some of the basidia. Also a large number of basidial types varying from the one described above were found.

In a considerable number of immature basidia, one of the nuclei occasionally may appear to be migrating through a pore in the cross wall, and this nucleus is usually constricted at the point where it passes through the wall (FIG. 2, *22, 23, 25, 27, 28*; 4, *E–G*). In one basidium, however, a nucleus without any constriction in it was found in the region of the cross wall (FIG. 2, *24*). Another basidium contained a nucleus which had obviously been cut in two by the developing septum (FIG. 2, *26*). Some of the mature basidia were observed to contain five nucleus-like bodies, instead of the usual four, but some of these bodies are abnormally small (FIG. 3, *1b, 2a*). The logical conclusion seems to be that a nucleus, caught in the region of a developing cross wall, has been cut into two parts, and that the nucleus was not migrating through the septum. The fate of these two parts is not known, but the chances are that they disintegrate.

The mature basidia show a great deal of variation. Although they are most commonly three-celled, they may also be two- or four-celled. The distribution of the four nuclei in these basidia is also very variable. Considering the three-celled basidia first, there are several variations of this type. The apical cell or the basal cell, instead of the middle one, may be binucleate and the other two cells uninucleate (FIG. 3, *3, 4*). Such basidia are not very common, however. Other three-celled basidia may contain a single nucleus in each cell, with the fourth nucleus remaining in the teliospore cell (FIG. 3, *7*); or sometimes the teliospore cell may contain a nucleus, one cell of the basidium may be without a nu-

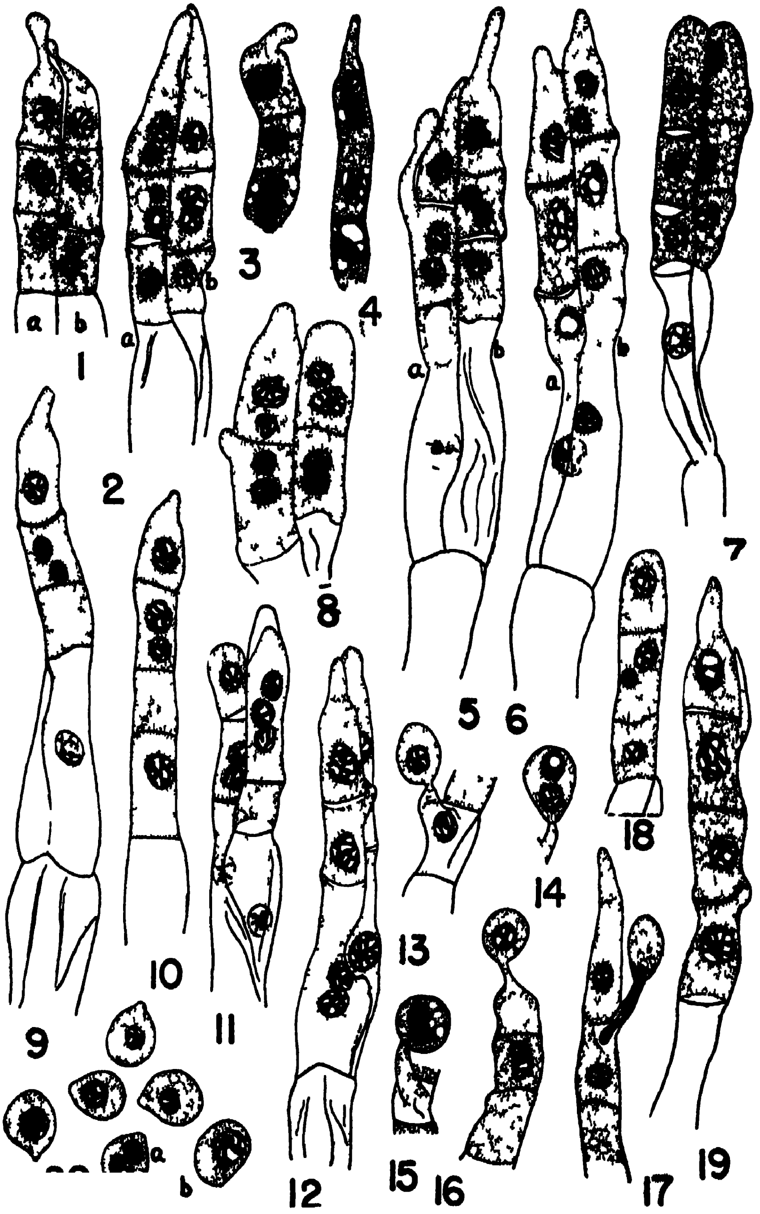

FIG 3 *Sphenospora kevorkianii*

cleus, another cell may contain two nuclei, and the third cell may be uninucleate (FIG. 3, *9*). Cells without nuclei have never been observed to germinate. Still other three-celled basidia may have their lowermost cell continuous with the teliospore cell, *i.e.* without a separating cross wall. In this case the nucleus ordinarily present in the lower cell is generally found in the teliospore cell (FIG. 3, *5a*). Rarely a teliospore cell continuous with the lowermost basidial cell may contain two nuclei and then the upper two cells of the basidium are uninucleate (FIG. 3, *12*). All basidial nuclei stranded in the teliospore apparently degenerate, along with the cytoplasm. Therefore, some of the three-celled basidia are capable of producing only two basidiospores (FIG. 3, *5a, 9, 12*).

A few basidia never develop more than two cells. A pair of such basidia were found to contain two nuclei in each cell (FIG. 3, *8*). Another contained three nuclei in the terminal cell with the other cell devoid of a nucleus, the fourth nucleus being in the teliospore (FIG. 3, *11*). Such a basidium would probably produce only a single basidiospore. It is possible that another septum would have appeared later in the trinucleate cell. On the other hand, I have observed a basidium with a uninucleate and a trinucleate cell in the process of germination. The basidium resembled the one shown in fig. 2, *19*, except that the sterigmata had appeared. Presumably the basidiospore produced by a trinucleate basidial cell would also be trinucleate. However, I have not observed such spores.

A four-celled basidium with a single nucleus in each cell, characteristic of most rusts, is a rarity in *Sphenospora kevorkianii* (FIG. 3, *19*). Such a basidium appears capable of producing four basidiospores. This is not true of some of the four-celled basidia, where one of the cells is binucleate and another devoid of a nucleus (FIG. 3, *10*). A single basidium was found to contain five nuclei (FIG. 3, *6*). This may mean that one of the nuclei in the basidium underwent a post-meiotic division.

DISCUSSION

There is a rather striking similarity in the basidial development of *Sphenospora kevorkianii* and *Septobasidium apiculatum* Couch, the development of the latter having been described by me in an

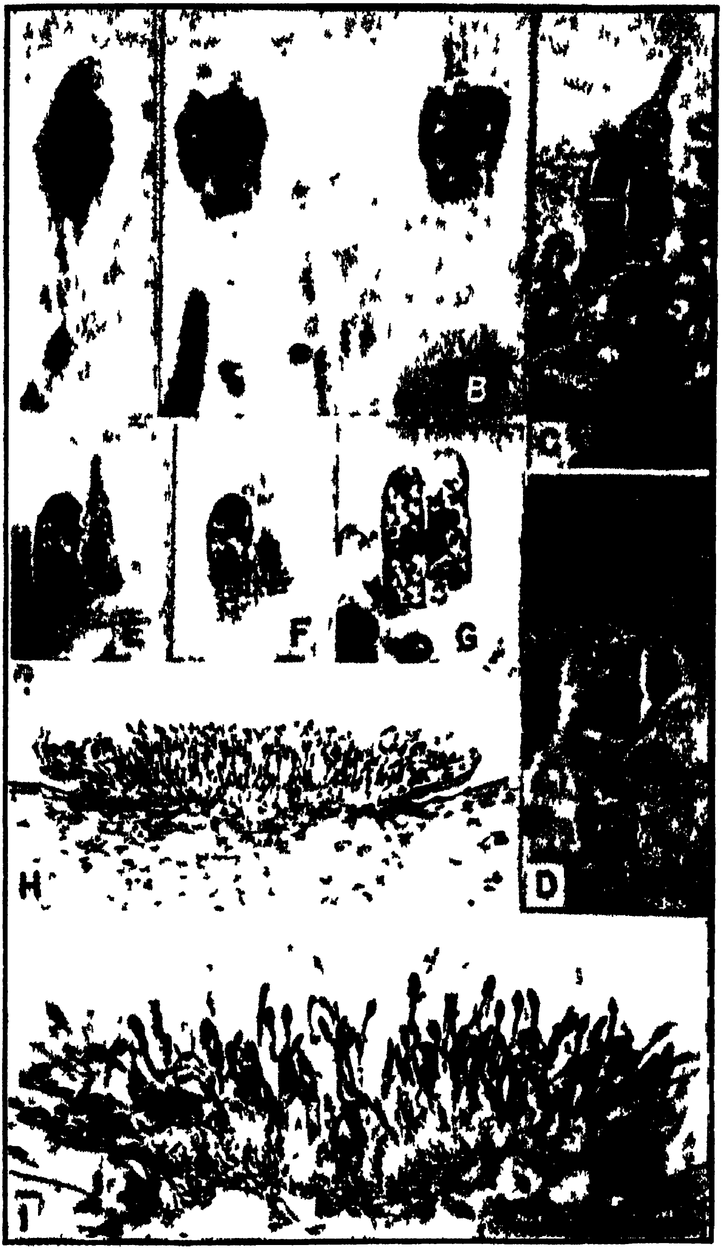

FIG 4 *Sphenospora kevorkianii*

earlier paper (1943). In both fungi there is often no apparent correlation between meiosis and cross wall formation in the basidium. In *S. apiculatum,* it is the basal cell of the basidium, rather than the middle one, which is generally binucleate; but, as in *Sphenospora kevorkianii,* any one of the three cells may be binucleate and sometimes a four-celled basidium with only uninucleate cells is produced. These two fungi evidently show parallel lines of phylogenetic development, a phenomenon which has been repeatedly observed in the rusts and the Septobasidiales.

The discharge of the nucleolus into the cytoplasm in the prophase of meiosis is not in agreement with what I found in the basidia of *Coleosporium helianthi* (Schw.) Arth. (1942). In the latter rust the nucleolus seems to divide into two parts, which probably separate and pass to opposite poles of the spindle. However, in the greater part of the literature on the subject, the nucleolus is more frequently described as being discharged into the cytoplasm, where it disintegrates.

The occurrence of both uninucleate and binucleate basidiospores in *Sphenospora kevorkianii* is of considerable interest. As a result of the manner in which nuclear division and septation occur in the basidium, the binucleate cell is likely to contain most frequently a nucleus from each of the two spindles of the second meiotic division. This further means that the two nuclei are very probably genetically unlike. Therefore, there exists the possibility that such a binucleate basidiospore is capable of producing, upon infection of the host, a dikaryotic mycelium. I have found no record of aecia or of an alternate host for any species of *Sphenospora,* but subepidermal pycnidia have been reported in the genus for the same host that bears the uredinia and telia. It seems probable, therefore, that the rusts of this group are autoecious. However, further research is necessary to establish the validity of this belief. If the rust is capable of leading an autoecious existence, one might expect the basidiospores to be capable of infecting the host. The abundance of uninucleate haustoria, in addition to some binucleate haustoria, in leaves of *Epidendrum* diseased by *S. kevorkianii* indicates that this is the case. Leaves of the orchid have not been inoculated with basidiospores of the rust, and no further evidence is available regarding their ability to infect the host.

In considering the possible phylogenetic origin of the fungus and its taxonomic position, a comparison might well be made first with the more familiar development of teliospores and basidia in *Puccinia* (Allen, 1933). The teliospores of the two rusts develop in essentially the same manner, except that in *Sphenospora* the septum dividing the spore into two cells is vertical instead of horizontal, and the spore wall does not thicken as in *Puccinia*. However, some species of *Puccinia*, such as *P. boutelouae* (Jennings) Holw., *P. levis* (Sacc. & Bizz.) Magn., and *P. flaccida* B. & Br., may have teliospores with septa varying from horizontal or oblique to vertical.

The genus *Diorchidium* Kalchbr. has a type of teliospore which appears to bridge the gap between the *Puccinia* and *Sphenospora* types. Here the teliospore is divided into two cells by a vertical septum, and the spore wall is typically thickened and brownish, instead of thin and hyaline as in *Sphenospora*. The species of *Puccinia* mentioned above produce some teliospores which intergrade with those found in *Diorchidium*. But in at least one species of *Diorchidium*, *D. piptadeniae*, the spore wall is only moderately thickened and pale in color. On the other hand, in *Sphenospora berberidis*, which is a rather atypical species, the teliospore wall becomes thickened above and is pale cinnamon in color. Even Dietel (1903), who founded the genus *Sphenospora*, later expressed some doubt as to whether this genus would stand. His observations on *D. piptadeniae* were responsible for this later view. Saccardo did not recognize *Sphenospora* as a valid genus, and he placed species described under that name in *Diorchidium*. Dietel (1928) finally placed *Sphenospora* in the tribe Ravenelieae of the Pucciniaceae.

Arthur (1925) assigned *Sphenospora* to the subfamily Skierkatae of the Aecidiaceae (Pucciniaceae) along with *Skierka*, *Ctenoderma*, and *Chaconia*. Its relationship with these last mentioned genera is obscure. *Skierka* and *Ctenoderma* have unicellular teliospores with deciduous pedicels; whereas *Chaconia* has sessile teliospores arising singly or in groups from enlarged basal cells in the telium.

Cummins (1941) suggests that *Sphenospora* may be related to *Ypsilospora*. He describes the latter genus as having unicellular teliospores in pairs at the tips of common pedicels. He further states that the arrangement of the two teliospores on a common pedicel is similar to the condition found in *Sphenospora,* except that the two spores have no common wall. Cummins attempts to strengthen this view with Sydow's description (1924) of the teliospores of *S. copaiferae* as ". . . am Septum meist ziemlich tief eingeschnurt," which apparently means that the two cells of the teliospore remain attached along the septum below but tend to separate above. This phenomenon occurs quite commonly in *Gymnosporangium,* where the cells of the teliospore often tend to separate at the septum after the spore has been in water for some time.

Linder (1944) appears to agree with Cummins that *Sphenospora* is allied to *Ypsilospora* by virtue of these similarities in teliospore development. However, such comparisons seem to me to be based more upon analogies than homologies. The description of *Ypsilospora* indicates that two one-celled teliospores arise independently at the apex of a common pedicel and that each remains unicellular. In *Sphenospora* a teliospore initial divides to produce two cells, one of which is the pedicel and the other the spore proper. This latter cell would appear to be homologous with *one* of the unicellular teliospores in *Ypsilospora,* although it later becomes two-celled by the formation of a vertical septum. It is possible that the so-called pedicel in *Ypsilospora* is homologous with the basal cell in the telium of *Sphenospora* and that the two spores produced at its apex are actually sessile. However, further developmental studies on the teliospores of *Ypsilospora* are needed before any conclusive comparisons based upon homologies can be made.

I feel that, until more extensive cytomorphological investigations have been made on other genera of rusts seemingly related to *Sphenospora,* the genus should be retained as a member of the tribe Ravenelieae of the Pucciniaceae, as previously designated by Dietel. In actuality, its teliospore development probably has more in common with the development in *Puccinia* than with that in *Ravenelia.* Therefore, it may later prove advisable to erect a new and intermediate tribe to include such genera as *Sphenospora* and *Diorchidium.*

SUMMARY

1. The cytomorphological development of the teliospores of *Sphenospora kevorkianii* is essentially like that described for *Puccinia,* except that the spore septum is vertical and the spore wall remains thin. At maturity each cell contains a single large fusion nucleus.

2. Paraphyses are produced in large numbers from the same cells in the telium that produce the teliospore initials. They are generally unicellular and binucleate, but are sometimes two-celled.

3. Each cell of the teliospore germinates to produce a basidium apically. Two meiotic divisions take place in the basidium, the nucleolus being discharged into the cytoplasm during the first division.

4. Four nuclei are produced in the developing basidium, which generally becomes three-celled, with one nucleus in each of two cells and two nuclei in a third cell. The septa are produced in an irregular manner, generally not directly correlated with the nuclear divisions.

5. Two- and four-celled basidia are also produced.

6. Some of the nuclei in the developing basidia appear to be cut into as they get in the way of the developing septa.

7. Mature basidia produce from one to four basidiospores, usually three. Spores produced by uninucleate cells of the basidium are uninucleate. Those produced by the binucleate cells are binucleate. There appears to be no nuclear division in the basidiospores at this time.

8. The taxonomic treatment of the genus *Sphenospora* by Dietel seems to be the most acceptable at present. Thus the genus is retained in the tribe Ravenelieae of the Pucciniaceae.

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DEPARTMENT OF BOTANY, BACTERIOLOGY, AND PLANT PATHOLOGY,
LOUISIANA STATE UNIVERSITY,
BATON ROUGE, LOUISIANA

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EXPLANATION OF FIGURES

FIG. 1, *1–17* (all figures × 1410). *1, 2,* basal cells with nuclei dividing conjugately; *3,* basal cell and initial cell; *4,* young teliospore with pedicel; *5,* young teliospore or paraphysis, basal cell budding out second initial; *6,* young teliospore with pedicel; *7, 8,* two-celled teliospores just after conjugate nuclear division; *9, 10,* two cells of same teliospore, showing nuclear fusion; *11–13,* stages in nuclear fusion in the teliospore; *14,* crushed teliospore with fusion nucleus (note nucleolus); *15,* mature teliospore with fusion nucleus in each cell (note nucleoli); *16,* unicellular, binucleate paraphysis; basal cell budding out a new initial; *17,* two-celled paraphysis.

FIG. 2, *1–28* (all figures × 1410). *1, 2,* mature binucleate paraphyses; *3, 4,* young basidia, each with fusion nucleus in leptotene; *5, 6,* prophase of first meiotic division, nucleolus being discharged into cytoplasm; *7,* late prophase with two nucleolus-like bodies apparently being discharged into the cytoplasm; *8,* anaphase spindle of first meiotic division; *9,* telophase of first meiotic division; *10,* binucleate basidium with two nucleolus-like bodies appearing in the cytoplasm; *11,* binucleate basidium; *12,* binucleate basidium with cross wall; *13–17,* stages in second meiotic division; *18,* unicellular, quadrinucleate basidium; *19, 20,* quadrinucleate basidium with single septum; *21,* mature three-celled basidium; *22–28,* nuclei in the region of the cross walls of the basidia.

FIG. 3, *1–20* (all figures × 1410). *1–7,* various types of three-celled basidia; *8,* a pair of two-celled basidia; *9,* three-celled basidium with one cell devoid of a nucleus; *10,* four-celled basidium with one cell lacking a nucleus; *11,* two-celled basidium with one cell empty and one containing three nuclei; *12,* three-celled basidium with lower cell continuous with the teliospore cell, the latter containing two nuclei; *13–15,* germination of binucleate basidial cells to produce binucleate basidiospores; *16,* uninucleate cell producing a uninucleate basidiospore; *17,* nucleus of binucleate cell passing up into basidiospore; *18,* basidial nuclei showing nucleoli; *19,* four-celled and quadrinucleate basidium; *20,* basidiospores, one binucleate (a) and one showing nucleolus (b).

FIG. 4, *E–I.* Photomicrographs. *A,* two-celled teliospore immediately after conjugate nuclear division. Note the two nuclei in each cell (also *see* FIG. 1, *7*). *B,* two-celled teliospores with a single fusion nucleus in each cell. *C,* mature basidia germinating (*see* FIG. 3, *5*). *D,* nucleus passing from binucleate cell of basidium into basidiospore (*see* FIG. 3, *17*). *E–G,* basidial nuclei in the region of the septa, *E* and *F* representing the same at slightly different levels. *H, I,* vertical sections through the telia, showing paraphyses, teliospores, and basidia. (*A–G,* × 1075; *H,* × 65; *I,* × 100.)

THE PRODUCTION OF SPORES IN SUBMERGED CULTURES BY SOME STREPTOMYCES[1]

FERNANDO CARVAJAL[2]

(WITH 7 FIGURES)

Foster et al. (2) reported the formation of submerged spores in shaken and aerated cultures of *Penicillium notatum* and *P. chrysogenum*, which previously had been known to form spores only on the aerial mycelium. This sporulation was first indicated to them by an insoluble greenish pigmentation which settled out with the other solid material from the broth. Microscopic examination of this material showed that typical conidiospore formation had occurred in the submerged cultures and that the green pigment was due to the presence of a considerable number of these spores.

Sporulation of microorganisms belonging to the genus *Streptomyces* is usually thought of as occurring on the aerial mycelium. The formation of spores in submerged cultures by species of *Streptomyces* has not been noted previously. In the course of mycological studies in connection with the production of streptomycin, submerged sporulation has been observed by the writer. A description of this phenomenon, which is also illustrated with microphotographs, comprises the subject of the present communication.

The various fermentation samples studied were from large fermenters and shake flasks maintained at 75° F.

The following streptomycin producing strains of *S. griseus* were used in these experiments: SL no. 842, SL no. 842–4, FC no. 2103, FC no. 1196 (all isolated from soil samples by the writer), and *S. griseus* no. 4 from Dr. S. A. Waksman. One non-streptomycin producing strain, *S. griseus* FC no. 3077, and other Actinomycetes such as *Streptomyces lavendulae* SL no. 752 (streptothricin pro-

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[1] Presented before the Mycological Society of America at Boston, Massachusetts, December 26–30, 1946.

[2] Contribution from Schenley Laboratories, Inc., Research and Development Division, Lawrenceburg, Indiana.

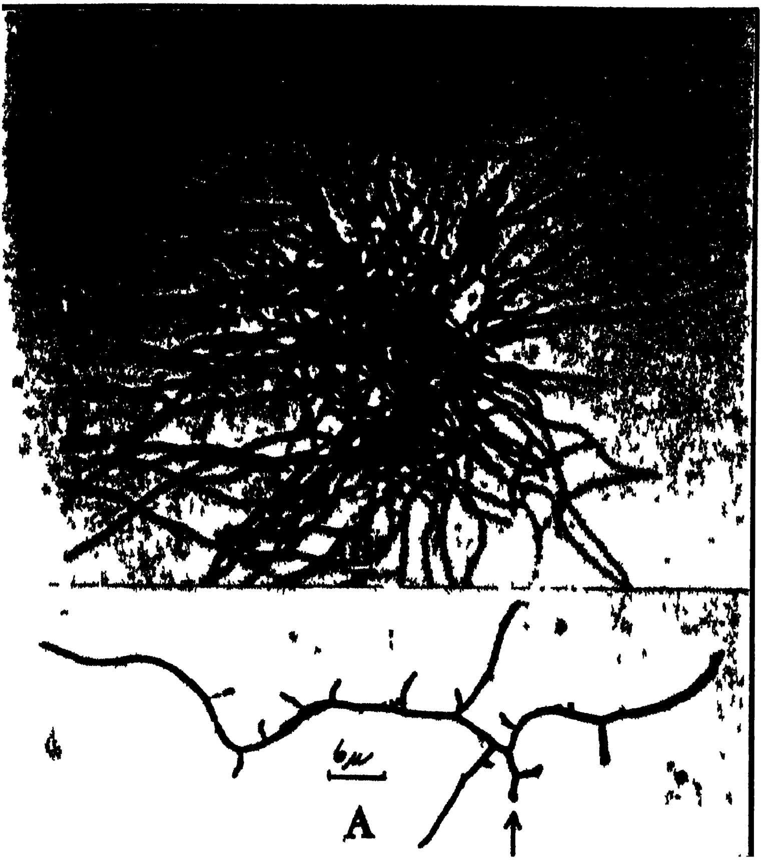

FIG 1 *Streptomyces griseus*

ducer); *Streptomyces* sp. FC no. 2969 and *Actinomyces albus* ATCC no. 618 (Krainsky's type species) were also employed in these tests.

Slides were prepared by drying smears of fermentation broth at room temperature, staining with Loeffler's methylene blue or with Poirrier's cotton blue, washing (to remove excess stain), drying, and then affixing the cover slips with Canada balsam.

When permanent slides were prepared from the aerial growth of sporulated colonies on the surface of the agar (FIG. 6*A* and *B*), a loop containing distilled water was moved over the colony. Then the film of water containing aerial mycelium spores in chains, etc. was smeared on a clean slide, fixed and stained. Mycelium and spores of the same strain of the organism grown in different media often showed different affinity for the stain.

SPORE PRODUCTION IN SUBMERGED LIQUID CULTURES

The fungus, *S. griseus*, undergoes certain morphological changes in submerged, aerated, liquid cultures which culminate with the completion of its life cycle by the production of submerged spores. The manner of spore formation in submerged cultures of *S. griseus* strains is much the same as that which occurs on the aerial mycelium on solid or liquid media (1). The spores are easily broken loose at their points of attachment and go into suspension in the agitated broth. In spite of the agitation brought about by stirring and aeration, long spore chains are often found in the broth (FIGS. 3, 4 and 5*A* and *B*). These spore chains probably are not fully mature; consequently they are quite resistant to breakage. The spores are of various shapes, mainly: oval, cylindrical, spherical, bean, or barrel shaped (FIGS. 3, 4, and 5).

The spores may be produced on sporogenous branches (FIG. 3, *B*), at the tips of vegetative mycelium, mycelial fragments may become entirely sporogenous (FIG. 4), a considerable part of the vegetative mycelium may become fertile (FIG. 5*A* and *B*), or spores may be formed in the germ tubes of germinating spores (FIG. 5*D*). The specialized sporogenous branches (FIG. 3*B*) are often clavate when young and arise from the mycelium usually singly or sometimes in groups of two or more from a single position on the mycelium. Many sporogenous branches may also arise from a single

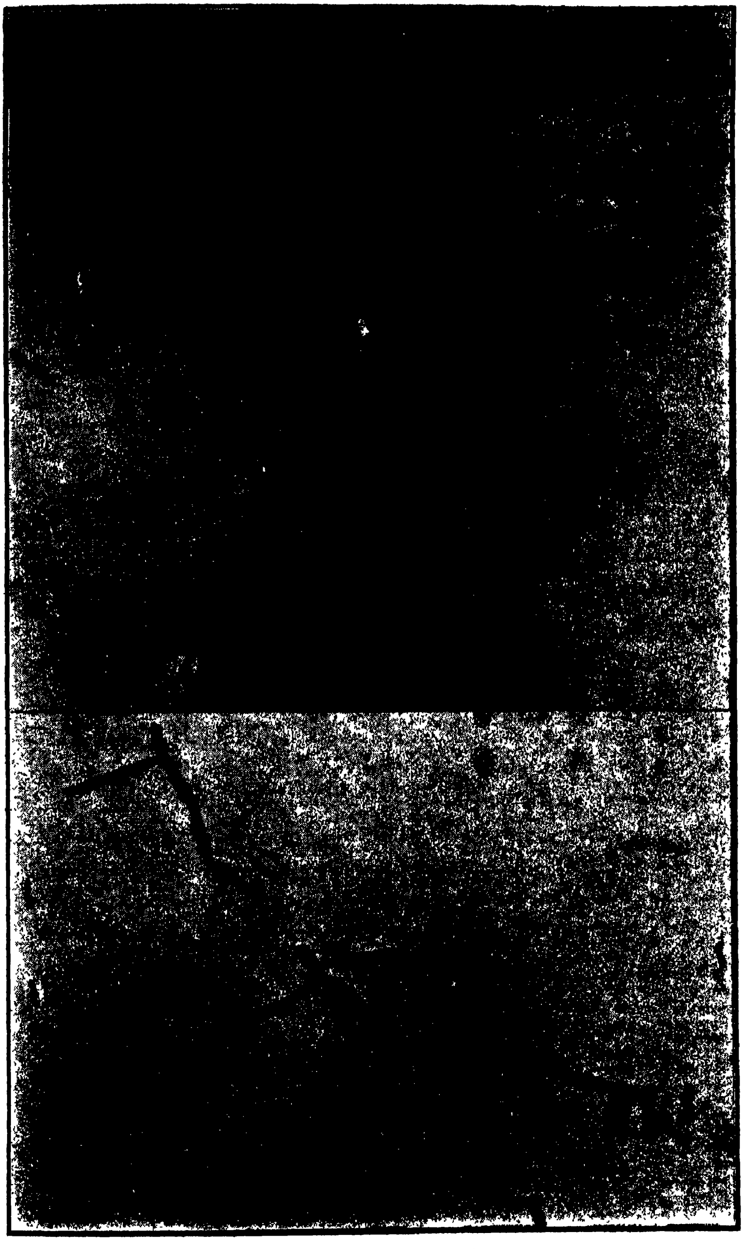

FIG. 2. *Streptomyces griseus.*

hypha. The point of attachment of sporogenous branches in fertile mycelium may be an apparently normal spore or one of irregular size and shape, *i.e.* T-shaped or triangular (FIG. 5*A* and *B*). One or more side chains may be attached to these spores so that the main axis and the secondary branches appear as a network of spores. Sometimes empty spaces are found between spores in the same spore chain. These empty spaces often appear to be collapsed and flattened so that the diameter appears to be larger than that of the rest of the spore chain.

The physiological and morphological characteristics of submerged spores and aerial spores appear to be similar. The submerged spores germinate normally by means of one to several germ tubes (FIG. 5*C*), and streptomycin production by the resulting thallus corresponds to that of the parent culture.

Production of spores in submerged cultures was not limited to strains of *S. griseus*. The morphological changes noted in submerged cultures of *S. griseus* were also observed (FIG. 6*C*, *D*, *E*, and *F*) in similar cultures of the following organisms: *Streptomyces lavendulae*, *Streptomyces* sp., a chromogenous type, and *Actinomyces albus* Krainsky (3) (*Streptomyces albus* [Krainsky] Waksman and Henrici).

Although the above organisms produce aerial spores in spiral chains, the spore chains produced in submerged cultures were straight (FIG. 6).

A. *Tank Fermentations.* The samples for examination were usually taken every twelve hours. During the first twelve hours after seeding of the broth with spores of *S. griseus*, the spores germinated and produced a typical fungous thallus (FIG. 1*A*). Between twelve and twenty-four hours they produced a considerable amount of mycelium which was rich in protoplasmic contents. Mycelial growth was quite rapid from 24 to 48 hours. The mycelium continued to produce new branches and at the same time vacuolation and empty portions in the mycelium appeared as empty tubes in fresh and in stained preparations (FIG. 2*A* and FIG. 3*A*).

There was some indication that the mycelium had broken at the empty spaces since fragments often were found with empty and collapsed ends both of which were separated from the turgid area by septa. Scattered mycelial fragments also were found through-

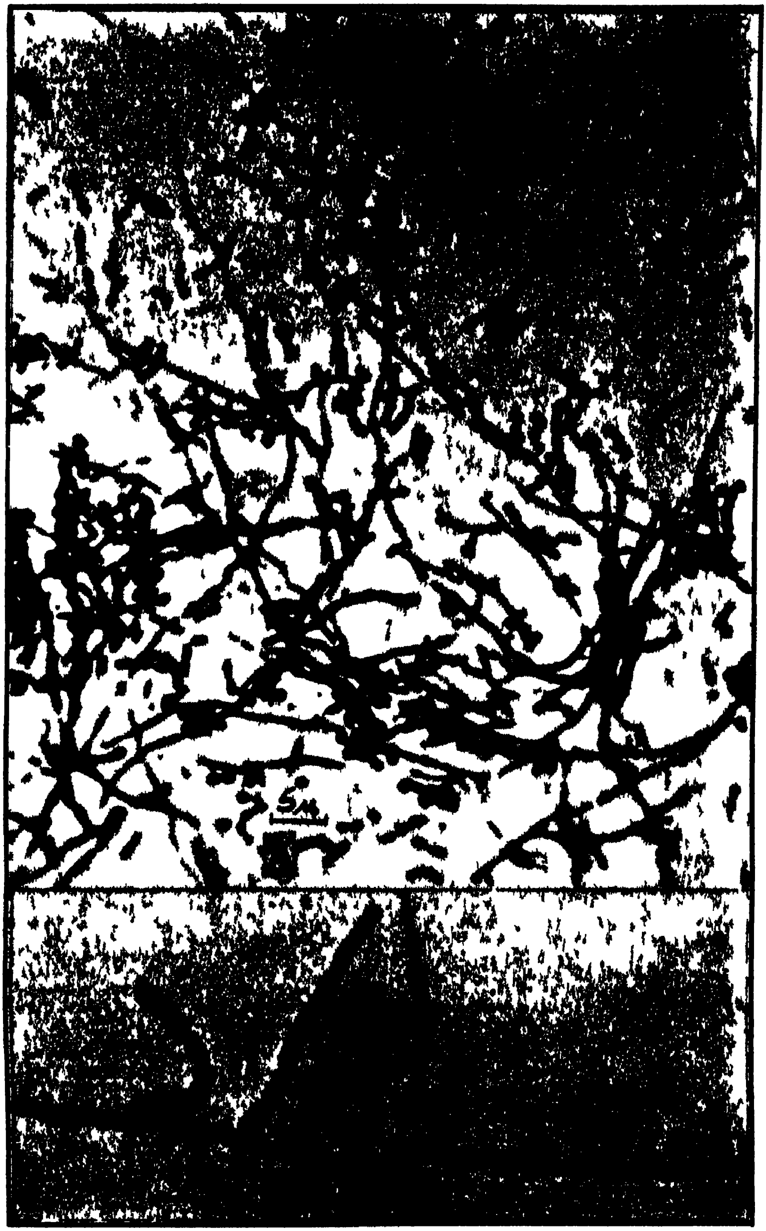

FIG 3 *Streptomyces griseus*

out the broth (FIG. 2, *A*). These mycelial fragments might germinate at any place by one to several germ tubes (FIG. 2, *B*) similar to those produced by the spores (FIG. 5, *C*), or they might produce spores (FIG. 4). Although disintegration of the mycelium occurred during fermentation, especially from 36 to 84 hours, a large number of submerged spores were usually produced at the same time.

In some instances little or no mycelium could be found in the broth but the presence of large numbers of viable spores was evident. These submerged spores could germinate in the same broth and produce new mycelium. The submerged spore production might start within twenty-four to sixty hours after the fermenters were seeded.

The life cycle of *S. griseus* was repeated if the fermenter was kept for 70 to 100 or more hours (TABLE II).

The following tables I and II are typical examples of fermentations using two different media.

Table I is typical of fermentations using corn steep liquor me-

TABLE I

SUBMERGED SPORE PRODUCTION AND MYCELIAL GROWTH OF S. GRISEUS IN LARGE FERMENTERS IN CORN STEEP LIQUOR MEDIUM

Fermentation Samples Time	Stage of Growth	pH	Streptomycin Activity (*mcg./ml.*)
0 hours	Original spores	7.2	0.0
12–24 hours	Spores germinating and developing a considerable amount of mycelium	6.78	0.0
36 hours	Mycelium profuse. Some vacuolation and empty portions in mycelium.	7.18	4.0
48 hours	Mycelium profuse. Some fragmentation and some cellular disintegration of mycelium evident. A few submerged spores produced.	7.02	55.0
60 hours	Fragmentation and disintegration of mycelium increasing. Considerable amount of submerged spores produced.	7.18	189.0
72 hours	Considerable fragmentation and disintegration of mycelium. Great amount of submerged spores produced.	7.28	250.0
84 hours	Considerable fragmentation and disintegration of mycelium. Profuse submerged sporulation. Some spores germinated.	7.23	250.0
88 hours	Similar to 84 hours but more sporulation and more spores germinated.	7.32	250.0

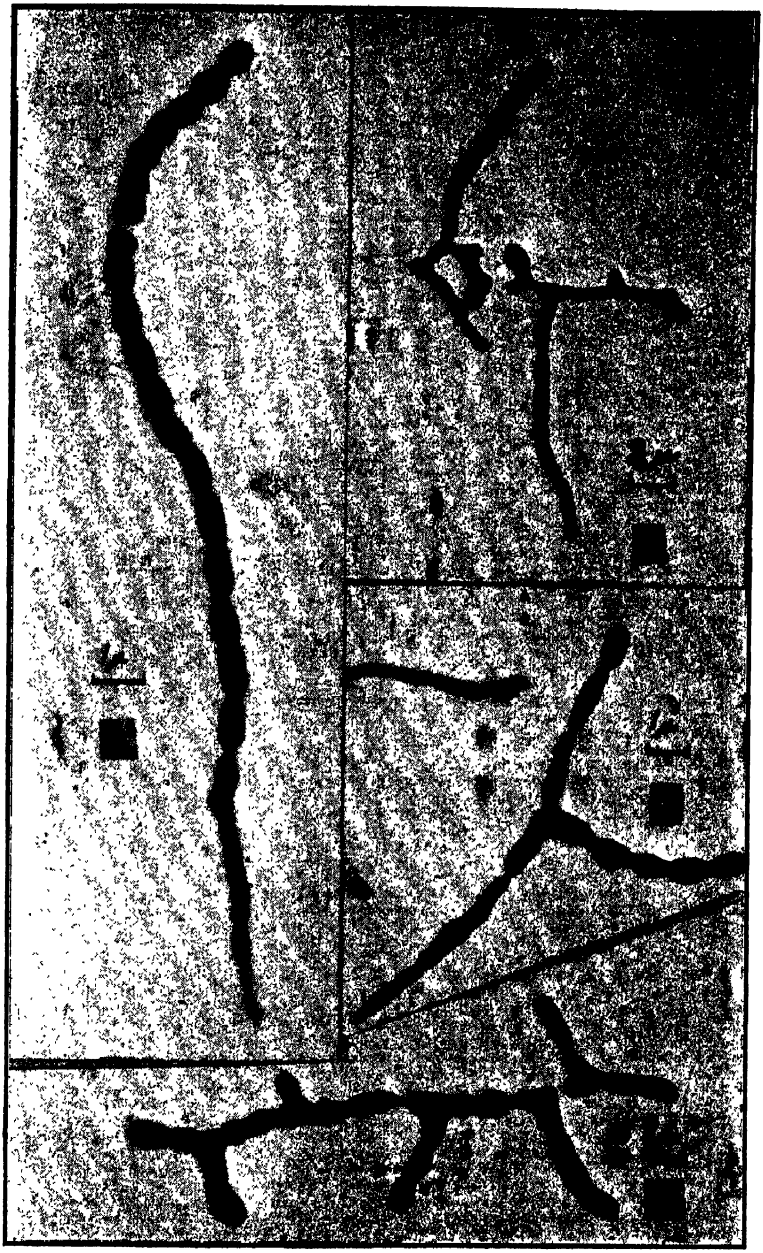

FIG. 4. *Streptomyces griseus.*

dium. In this medium when submerged sporulation started streptomycin production rose rapidly.

Table II is typical of fermentations in a tank using synthetic medium. It appears that good submerged sporulation occurred before any streptomycin was produced.

TABLE II

SUBMERGED SPORE PRODUCTION AND MYCELIAL GROWTH OF S. GRISEUS IN LARGE FERMENTERS IN SYNTHETIC MEDIUM

Fermentation Samples Time	Stage of Growth	pH	Streptomycin Activity (*mcg./ml.*)
0 hours	Original spores	7.48	0.0
12 hours	Spores germinating and developing a considerable amount of mycelium. Some vacuolation and empty portions in mycelium observed.	7.61	0.0
24 hours	Mycelium well developed and some fragmentation and disintegration of mycelium accompanied the production of a considerable number of submerged spores.	7.28	0.0
36–48 hours	Heavy sporulation evident and vegetative mycelium almost completely disappeared. Many spores germinated and others swollen.	7.32–7.22	0.0
60 hours	Greater sporulation evident and new mycelium developing from new spores.	7.06	9.0
72 hours	Heavy sporulation present and good mycelium developing from new spores.	6.93	16.0
84 hours	New mycelial growth increasing in amount, spore count decreasing greatly.	7.48	39.0
96 hours	New mycelium very profuse, rich in protoplasm and a very few spores evident.	7.29	85.0
108 hours	Large amount of sporulation evident; very little vegetative mycelium present.	7.21	87.0
120 hours	Sporulation increased over that evident at 108 hours. Mycelium almost absent.	7.09	158.0
132 hours	Amount of sporulation increased, mycelium practically all gone. Spores germinating and producing more spores at their tubes and young mycelial branches.	6.90	95.0

A greater submerged sporulation was produced in a shorter time of fermentation in synthetic medium than in the corn steep liquor medium. The relationship between the increase in submerged sporulation and streptomycin production depends largely on the type of medium used.

B. *Shake Flask Cultures.* Several experiments were carried out with shake flask cultures grown in 500 ml. Erlenmeyer flasks, each

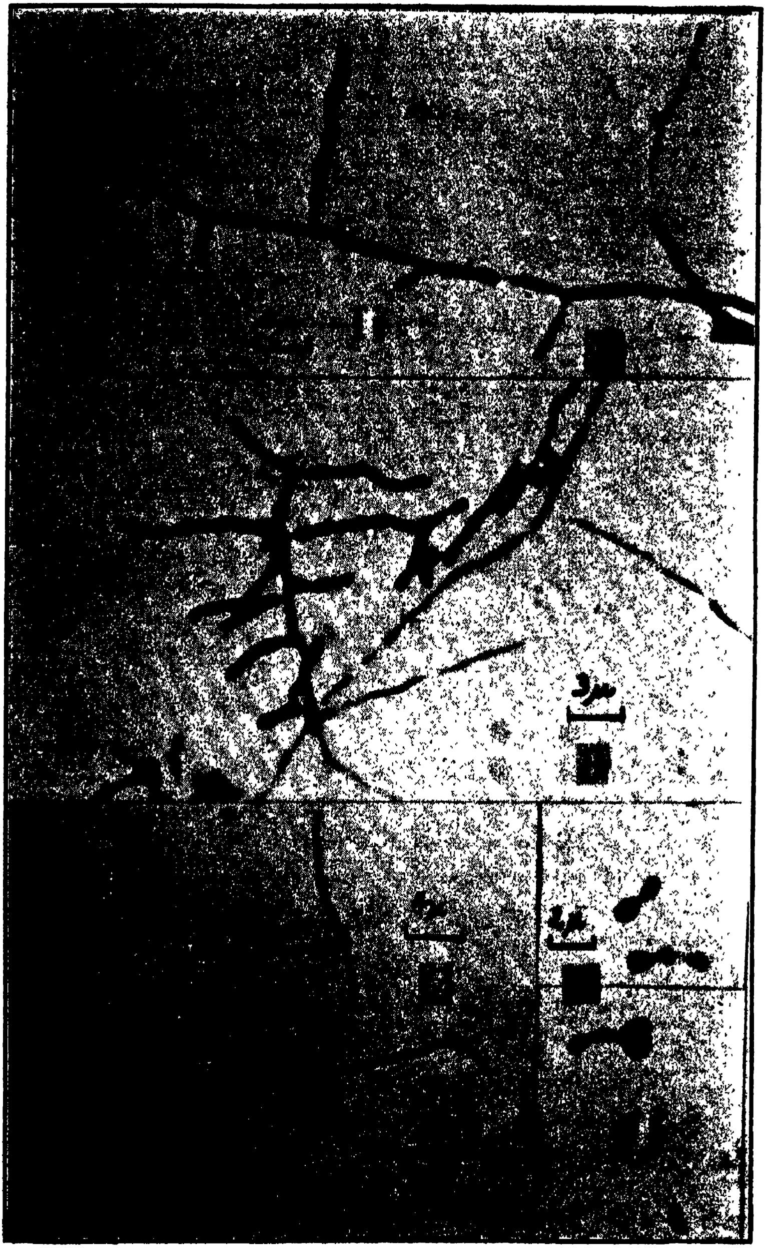

FIG. 5. *Streptomyces griseus.*

containing 100 ml. of medium which had been seeded with 1 ml. of spore suspension in sterile water. In order to avoid aerial growth of mycelium on the sides of the flasks and spore formation from such growth, the contents of each flask were transferred daily to another clean, sterile flask. Each flask was also shaken by hand several times during the day and its position in the shaker changed by a quarter turn. Good results were obtained with the following media. 1. Corn steep liquor 15.0 ml. per 1000 ml. of distilled or tap water. 2. Beef extract (Difco) 7.0 gm. per 1000 ml. of distilled or tap water 3. Dextrose 10.0 gm., peptone 5.0 gm., beef extract 3.0 gm., NaCl 5.0 gm. per 1000 ml. of distilled or tap water. 4. Dextrin 25 gm., peptone 5.0 gm., beef extract 3.0 gm., NaCl 5.0 gm. per 1000 ml. of distilled or tap water.

S. griseus in shake flask cultures was observed to undergo morphological changes similar to those which occurred in the large fermenters; however, in the shake flasks the process was usually much slower. Good sporulation usually occurred at ages of two to six days.

In a modification of Foster's medium: manioc 20.0 gm., $NaNO_3$, 6.0 gm., KH_2PO_4 1.5 gm., $MgSO_4 \cdot 7H_2O$ 0.5 gm., $CaCl_2$ 25.0 gm., tap water 1 liter, the formation of loose mycelial wefts (FIG. 1*B*) and of a large amount of compact pellets (FIG. 1*C*) occurred from 1 to 3 days; however, subsequent submerged spore production was very poor.

A non-streptomycin producing strain, *S. griseus* FC no. 3077, in shake flasks produced better sporulation in 1 to 3 days than any of the *S. griseus* streptomycin-producing strains did under identical conditions.

SUBMERGED COLONIES OF S. GRISEUS IN SOLID NUTRIENT AGAR

The strains of *S. griseus* employed in this work readily sporulated in completely submerged colonies in nutrient agar (dextrose 10.0 gm., peptone 5.0 gm., beef extract 3.0 gm., NaCl 5.0 gm., agar 15.0 gm., water 1000 ml.) in Petri plates at pH 7.0, at room temperatures (75–85° F.). Good spore formation has been observed two to twelve days after seeding the agar with spores.

The submerged sporulated colonies were circular, nearly colorless and opaque; concentric-growth rings and sectors often appeared

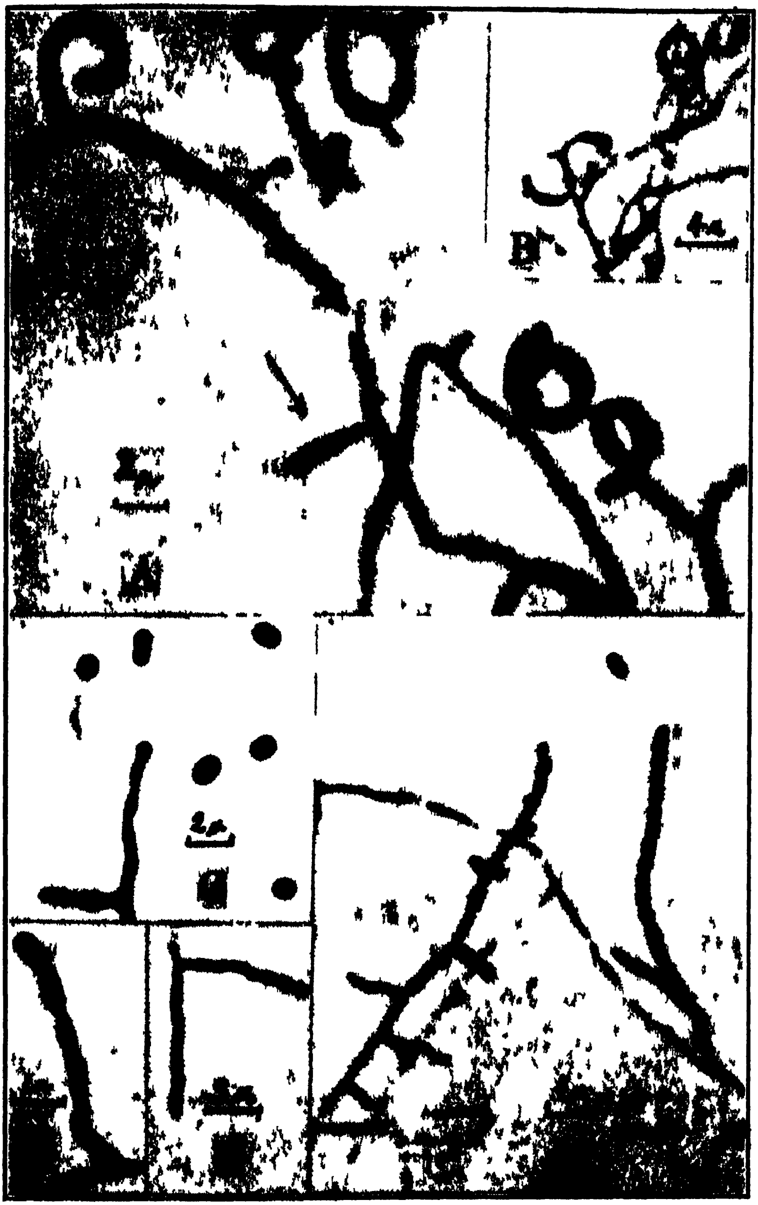

FIG 6 Spore formation in species of *Streptomyces*

after several weeks. In submerged well-sporulated colonies, it was often difficult to find typical mycelium since almost all of the mycelium had become fertile or disintegrated. Here, the spores were formed in a manner similar to that found in submerged liquid cultures. Very long spore chains were often produced (FIG. 7) and the mature spores might germinate and develop normal mycelium or secondary spore chains. Submerged mycelium of *S. griseus* no. SL 842 produced spores in a shorter period of time than the other *S. griseus* strains under identical conditions. Crowded colonies sporulated in a shorter time than did the well separated ones.

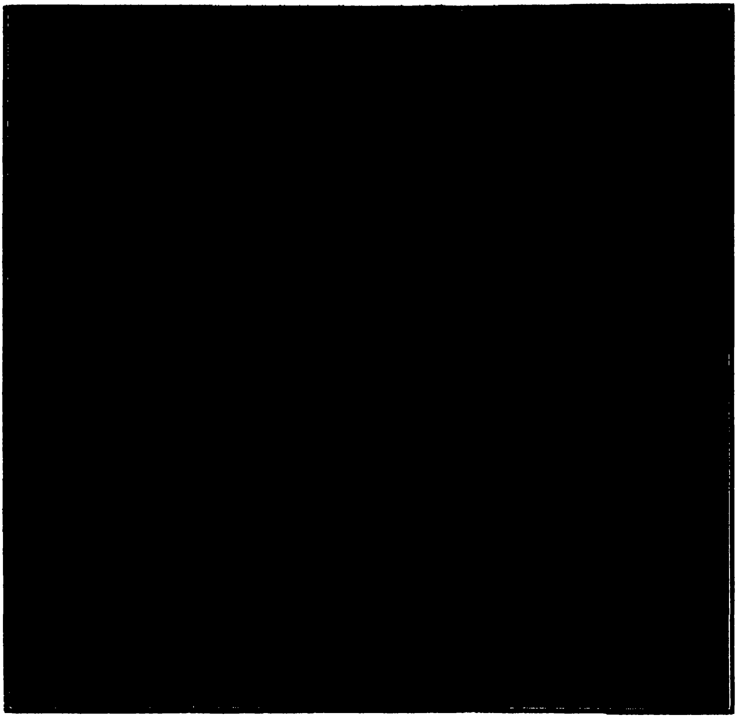

FIG. 7. Spore formation in *Streptomyces griseus* on solid media.

The study of submerged colonies of Actinomycetes in solid medium might be advantageous in cytological work on nuclear behavior, septation, reproduction, etc. The spores and mycelium in all stages are well preserved *in situ,* they stain very well and show the cytoplasmic contents clearly. Smears and microtome sections of this material are easily prepared.

SUMMARY

1. Information on the life cycle of the fungus *S. griseus* in submerged cultures is reported. The spores first germinated and produced profuse vegetative and typical fungous mycelium. Vacuolation, fragmentation and cellular disintegration of the mycelium was evident during fermentation in deep cultures, accompanied usually by the formation of large numbers of spores.

2. Submerged spores could be produced in a shorter time and in much larger quantities than spores produced on the aerial mycelium on the surface of solid or liquid media.

3. The mycelial fragments may germinate at any place by one to several germ tubes, similar to those produced by the spores.

4. In some instances at a certain age of fermentation, little or no mycelium was found in the broth; but the number of viable spores was profuse.

5. Submerged spore production may start within twenty-four hours after the fermenters are seeded. The submerged sporulation in large fermenters usually appears in a shorter time than in shake flasks.

6. All the *S. griseus* strains studied produced spores in submerged cultures. Some differences were found among strains in regard to the time and amount of sporulation.

7. The spores were found to be formed in chains: (1) In sporogenous branches arising from the vegetative mycelium; (2) at the tips of vegetative mycelium; (3) in the mycelium, in the main axis and secondary branches; (4) in mycelial fragments; and (5) in the germ tubes of spores and mycelial fragments.

8. The spores produced in submerged cultures were smooth and wettable. The physiological and morphological characteristics of submerged spores and of the aerial spores produced on the mycelium on solid or liquid media were similar.

9. Other species of the genus *Streptomyces, S. lavendulae, S. albus* and a *Streptomyces* sp., produced submerged spores in deep cultures. The morphological changes exhibited by these organisms during fermentation were very similar to those of *S. griseus* strains.

10. Colonies of *S. griseus*, submerged in nutrient agar, produced a large number of spores within two to twelve days at room temperature.

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DESCRIPTION OF FIGURES

FIGURE 1. *Streptomyces griseus* No. 2103, submerged cultures. A. Young thallus developing from single spore (arrow). B. Mycelial weft from a 48 hour culture. C. A compact pellet from a 48 hour culture.

FIGURE 2. *S. griseus* No. 2103, 48 hour submerged culture. A. Fragmented mycelium. Note empty portions of mycelium. B. Six mycelial fragments germinating by germ tubes.

FIGURE 3. *S. griseus* No. 2103, 60 hour submerged culture. A. Submerged spore formation and vegetative mycelium. B. Young spore chains borne on vegetative mycelium.

FIGURE 4. *S. griseus* No. 2103, 60 hour submerged culture. A. Young spore chain, note differences in size and shape of spores. B, C, and D. Spore chains. Note size and shape of spore connecting different spore chains.

FIGURE 5. *S. griseus* No. 2103, 60-hour submerged culture. A and B. Spore formation throughout the ramified mycelium including the main axis and secondary branches. Note (A) spores connecting different branches. C. Germination of submerged spores by 1–3 germ tubes. D. New spores produced at germ tubes of recently germinated spores.

FIGURE 6. Other Actinomycetes. A and B. *Streptomyces* sp. No. 2969. Aerial spore formation. A. A young clavate and septate sporogenous hypha (arrow) rising from the vegetative mycelium. Note curled spore chains. B. Formation of aerial spore in clavate and twisted sporogenous branches and their relation to the vegetative mycelium. C. *Streptomyces* sp. No. 2969. Submerged spore formation. Young spore chains and ripened scattered spores. D and E. *Streptomyces albus* (ATCC No. 618). Submerged spore formation. D. Young sporogenous hyphä born on vegetative mycelium. E. Young spore chains. F. *Streptomyces lavendulae* No. 752. Submerged spore formation and its relation to the vegetative mycelium.

FIGURE 7. Production of submerged spores of *S. griseus* No. 2103 in solid nutrient agar after 6 days. One spore (arrow) connecting spore chains to the main axis. From unstained and living preparations.

NEW OR OTHERWISE NOTEWORTHY SPECIES OF TUBERALES

HELEN M. GILKEY

(WITH 17 FIGURES)

Since the publication in 1939 of Tuberales of North America, the author has had opportunity to study further collections of fungi belonging to this order and the gleanings from these investigations are recorded in the following notes. They include one new genus, four new species, a new interpretation of a former species, and considerable extension of range for certain previously known members of the Tuberales.

The types of all new species are deposited at Oregon State College.

Caulocarpa gen. nov.

Ascomatibus carnosis, stipitatis, lente lobatis; interiore in cava partito, parietibus cavorum hymenio praeditis; gleba lacunis ad ascomatis superficiem apertis praedita; ascis cylindricis, octosporis; paraphysibus exilibus; sporis uniseriatis, levibus.

Ascocarp fleshy, stipitate, somewhat lobed, internally separated by partitions into hollow, hymenium-lined chambers opening to surface at furrows between lobes; asci long, slender, eight-spored; paraphyses equaling asci, narrow, septate, not swollen at apex; spores uniseriate, ellipsoid, small, smooth.

The genus *Hydnotrya* has previously been expanded by the present writer to accommodate several American entities which, although differing widely in certain respects from European species of the genus, yet appear closely related to them. A still further expansion might allow admission of the fungus here described, but such extreme attenuation of the original concept of the genus *Hydnotrya* seems unjustifiable.

The partitioning of the ascocarp into outward-opening empty chambers possessing hymenium-lined walls, is *Hydnotrya*-like. But in previously known *Hydnotrya* species, these chambers are either labyrinthine or anomalous in form; the paraphyses are enlarged at the tips and, at external openings, continue into the ascocarp surface as swollen-tipped hyphae which form a superficial velvety "pile"; the asci are clavate with irregularly arranged spores, or cylindrical with spores uniseriate, in either case the spores nearly or completely filling the ascus. In the fungus under discussion, the chambers are large, few, definite in form and not at all labyrinthine; the paraphyses are not swollen-tipped and do not continue into the ascocarp surface as hairs; both paraphyses and asci are conspicuously long and slender; and the small spores are crowded into the distal third or half of the ascus. In addition, the possession of a conspicuous stipe distinguishes the fruiting body of this fungus from any known species of *Hydnotrya*. In the writer's opinion, this combination of dissimilarities provides sufficient basis for the establishment of a new genus related to *Hydnotrya*.

TYPE SPECIES: *Caulocarpa montana*.

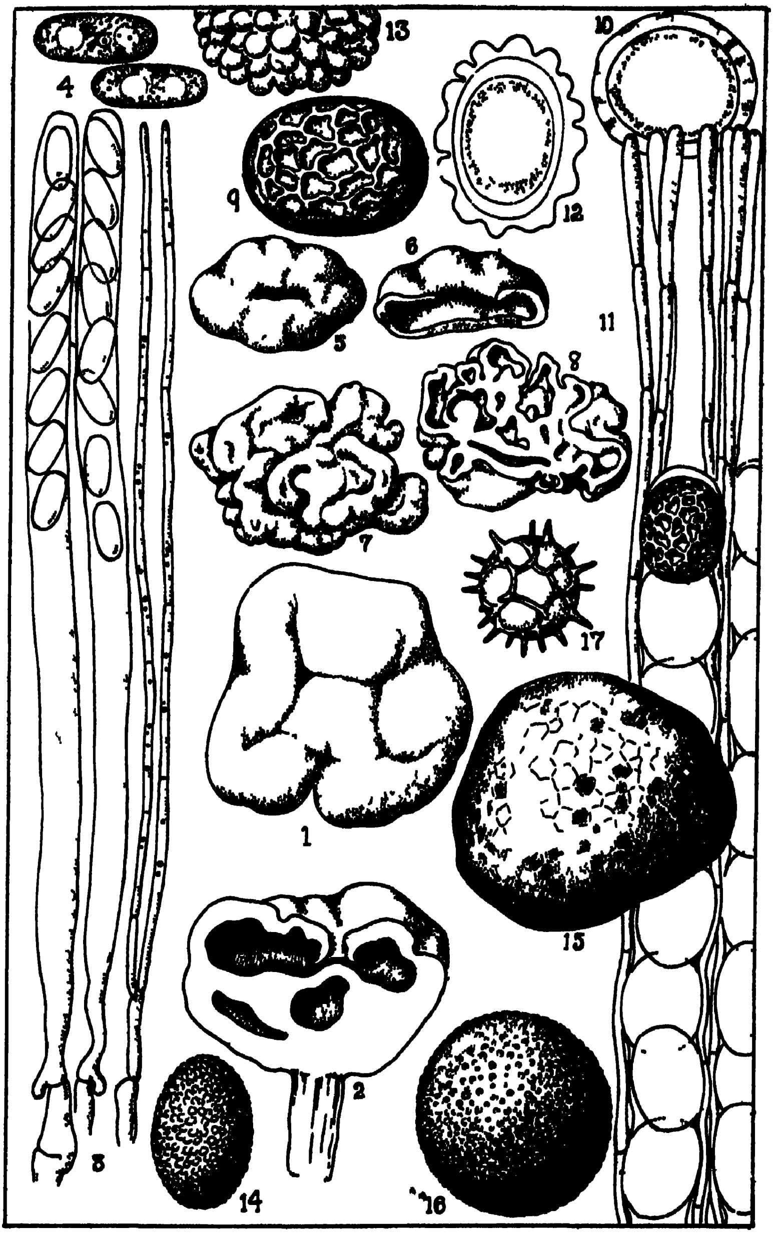
Caulocarpa montana sp. nov. (FIGS. 1–4)

Ascomatibus brunneis, carnosis, globosis aut lente depressis, 2–3.7 cm. diam., lente lobatis, stipitatis; interiore in cava partito, parietibus cavorum hymenio praeditis; textis corticis prosenchymaticis; textis subcorticis laxe hyphalibus; ascis 320 × 10–12 µ; paraphysibus exilibus, longitudine ascis aequis; sporis ellipsoideis, 10–17 × 6–8 µ, pellucidis, levibus, juvenilibus uni aut imperfecte biseriatis, maturis uniseriatis.

Ascocarp Dresden brown (R.), fleshy, nearly globose or slightly flattened, 2–3.7 cm. in diam., nearly regular but with a few thick lobes above, at base narrowed abruptly into a stipe 1 cm. or more long; interior of ascocarp partitioned partially or completely into large empty chambers lined with closely-packed hymenial palisade; cortex compactly prosenchymatous; subcortex and partitions consisting of loosely interwoven conspicuously irregular hyphae; asci 320 × 10–12 µ; paraphyses septate, very slender, acute at apex, equaling asci in length; spores ellipsoid to oblong, with rounded ends, smooth at least at first, 10–17 µ, colorless, generally occupying apical one-third to one-half of ascus.

OREGON: Hat Point (alt. 5500 ft.), margin of Snake River Canyon, Wallowa Co., beneath duff of coniferous grove, A. M. and D. P. Rogers, **type** (*284* H. M. G.).

This fungus, though collected only once, is known from several specimens in various stages of development. Most specimens ob-



FIGS 1–17

viously are slightly immature, at which stage the spores are clearly hyaline, smooth, and more or less biseriate in the ascus. As the spores enlarge and assume their characteristic and definite form, they become uniseriate, and their state of maturity is judged from these characters. Whether, however, any of the spores are completely mature, also whether eventually there may be a slight roughening of the surface, cannot be determined with certainty; though there is a faint suggestion of the latter. These studies will be continued when the area in which the fungus was discovered can again be visited.

So far as seen, this is a completely and permanently hypogaeous form, covered an inch or more by coniferous duff.

Hydnotrya variiformis sp. nov. (FIGS. 5–11)

Ascomatibus 0.7–3 cm. diam., argillaceis, subdepressis, regularibus aut penitus lobatis, superficie minute velutinosis; caverna fere simplice aut gleba compactis plicis composita; textis corticis externi pseudoparenchymaticis, interne in stratum compacte hyphalem transformantibus; ascis cylindricis aut lente clavatis, 240–280 × 24 μ; paraphysibus ultra ascos 120–140 μ prominentibus; sporis ellipsoideis, brunneis, juvenilibus uni aut rare imperfecte biseriatis, maturis perfecte uniseriatis, minute lacunosis, 24–28 × 32–36 μ.

Ascocarp 0.7–3 cm., cinnamon-buff (R.) to cream-buff (R.), somewhat paler within; form more or less globose to somewhat depressed, minutely velutinous without, exceedingly variable within, from *Peziza*-like with simple cavity and conspicuous opening, to extremely lobed with interior cavity reduced to many small chambers and narrow branching canals among crowded and fused folds, opening obscurely to the surface at several points; cortex pseudoparenchymatous without, changing to "tissue" of intertwined branching hyphae running perpendicular to asci; asci 240–280 × 24 μ, somewhat clavate at first, with developing spores sometimes incompletely biseriate, becoming cylindrical at maturity with spores strictly uniseriate; paraphyses slender, 6 μ thick, extending 120–140 μ beyond asci, tips slightly enlarged; spores 24–28 × 32–36 μ, rounded-oblong or ellipsoid, yellow-brown, minutely and irregularly lacuno-rugose.

CALIFORNIA: Mt. Shasta, Siskiyou Co., W. B. Cooke, **type** (*13371* Cooke; *288* H. M. G.); (*285–287, 289–299, 303–304* H. M. G.).

OREGON: Monument Peak, Linn Co., A. M. Rogers (*321* H. M. G.); Mt. Chintimini (Mary's Peak), Benton Co., Dr. D,

P. Rogers (*356–357* H. M. G.), Beulah and H. M. Gilkey (*281* H. M. G.); Black Rock Lookout, Douglas Co., Daisy Overlander (*355* H. M. G.).

Specimens of this species were collected almost simultaneously, at an altitude of 4000 to 8000 feet, upon widely separated mountain peaks. The spores, in shape, resemble those of *H. ellipsospora* and *H. yukonensis;* but they differ from both and from those of all other known species of *Hydnotrya* in their pitted and wrinkled surface.

The ascocarp exhibits wider variation than has previously been known in any single species of this genus. The simple *Peziza*-like shape found frequently in this species has typical *Gyrocratera* characters of a hollow fruiting body with a single apical opening. The interior, which is lined by hymenium, may be even, or may be complicated by projections from the inner surface. On the other hand, the extremely complicated forms, which also are common in this species, are typically *Hydnotrya*-like, in Fischer's sense (Mykolog. Beitr. **33**: 108–114. 1927), for the hymenium-lined interior is divided, by the fusion of folds, into canals and chambers which may open externally at several points.

This species, by closing the gap between *Gyrocratera* and *Hydnotrya* and identifying them as one, simplifies the explanation of relationship in our American species, several of which have been discovered since Fischer's paper was published.

Hydnotrya yukonensis sp. nov. (FIGS. 12–13)

Ascomatibus 1.5 × 2.5 cm. diam., brunneis, penitus lobatis, superficie minute velutinosis; gleba plicis compactis et irregularibus nonnumquam anastomosantibus et fossas longas labyrinthiformesque et cubicula formantibus composita; textis corticis prosenchymaticis; ascis cylindricis aut lente clavatis, 240–280 × 16–20 μ; paraphysibus ultra ascos 60–100 μ prominentibus; sporis ellipsoideis, juvenilibus uni aut rare imperfecte biseriatis, papillatis, pallide brunneis, 28 × 32–36 μ.

Ascocarp reaching 1.5 × 2.5 cm. in diam., wood-brown (R.), much convoluted, surface minutely velutinous; interior compact, penetrated by canals and chambers; cortex coarsely prosenchymatous, changing within gradually to smaller-celled prosenchyma and to loose branching hyphae, superficial cells forming septate hairs; subhymenial layer frequently penetrated by large branching hyphae, and subhymenial asci occasionally present; asci cylindrical or slightly clavate at first, 240–280 × 16–20 μ; paraphyses 60–100 μ longer than asci, scarcely or not at all swollen at apex; immature spores hyaline, ellipsoid, somewhat biseriate in ascus; at maturity pale yellow-brown, strictly uniseriate, 28 × 32–36 μ, papillose.

YUKON: Mayo Landing between Whitehorse and Dawson, coll. Catherine Broadfoot, **type** (Central Exp. Farm, Ottawa, also fragment in H. M. G. collection, No. *353*). Collected between 61° and 64° N. lat., at 4500 ft. alt. Submitted by Dr. D. B. O. Savile, Jr. Plant Path., Central Exp. Farm, Ottawa.

In spore development, this species closely resembles *H. carnea,*. *H. Tulasnei,* and *H. cubispora,* in which this process previously has best been known. The spore at first appears hyaline; later the epispore becomes visible as a more or less cubical block in which the hyaline spore proper appears embedded; and eventually the epispore takes its mature shape molded about the cell proper, but with coarse superficial sculpturing. In *H. cubispora,* in which the process is particularly conspicuous, the epispore at maturity (especially of the terminal spore of the ascus) frequently retains permanently its earlier cubical form, the sculpturing sometimes consisting principally of thickened angles without definite papillae. In all three of the above-mentioned species, the original hyaline cell is globose, any elongation such as often is found in the terminal spore of *H. cubispora* being due only to irregularly-distributed thickenings of the epispore.

The definitely ellipsoid spore shape of *H. yukonensis* links this species with the previously known *H. ellipsospora* and with *H. variiformis,* described in this paper. From *H. ellipsospora* it differs, together with other characters, in the much larger spores, very different spore surface, and in the long paraphyses. It has several characters in common with *H. variiformis,* including size and shape of spores, comparative length of asci and paraphyses, and subalpine habitat. However, its papillose spores bear no resemblance, except in size and shape, to the unique lacunose spores of the latter species; and structural differences further separate the two.

GEOPORA GLABRA Gilkey

Since the publication in 1939 of *Geopora glabra* (Tuberales of North America, Ore. State Col. Mono., Bot. 1), further opportunities for study of this fungus have revealed that the species was established upon immature specimens in which the spores were smooth and hyaline, that mature spores are minutely sculptured, and that definite external openings from the hymenium may be seen in mature ascocarps. The possession of these characters removes the organism from *Geopora* and establishes it as *Hydnotrya*. The spores of all species of *Hydnotrya* are conspicuously hyaline until a very late stage of development, and closely resemble mature spores of *Geopora, Barssia,* and *Pseudobalsamia.*

This species of *Hydnotrya* can be, in size of spores, compared with only one species heretofore described, namely *H. ellipsospora.* It differs from earlier-known specimens of the latter in the complex ascocarp, distinguished by folds and hymenial projections which partition the structure into many canals and chambers. Further, the spores of the type collection of *H. ellipsospora* are typically smaller and somewhat more ellipsoid. However, *H. variiformis,* described in the present paper, demonstrates to the author that extremes in ascocarp configuration can no longer be reckoned among criteria to separate *Hydnotrya* species; and the same may be said for spore shape and size in other genera, and therefore, perhaps, in this.

Spore markings appear identical in *H. ellipsospora* and the organism under discussion whereas shape and size vary considerably in both. Therefore *Geopora glabra* is reduced to synonymy under *Hydnotrya ellipsospora,* with the following emended description:

HYDNOTRYA ELLIPSOSPORA Gilkey emend. (FIG. 14)

Univ. Calif. Pub. Bot. **6**: 307 (1916); Sacc. Syll. Fung. **24**, Sup. Univ. **10** (1928); Fischer, Die natür. Pflanz. Band **5b** (VIII): 23 (1938). *Geopora glabra* Gilkey in Tuberales of North America, Ore. State Col. Monor., Bot. **1**.

Ascomatibus plicis laxis aut compactis compositis; sporis 10–16 × 14–(raro) 19 μ.

Ascocarp from a simple structure consisting of loose folds casually joined, to a compact complicated arrangement of folds and projections separating numerous canals and chambers; spores 10–16 × 14–(rarely) 19 μ.

CALIFORNIA: Pacific Grove, N. L. Gardner and M. B. Nichols, **type** (*316* U. C. Herb.); Saratoga, H. E. Parks (*295* Parks; *18* H. M. G.); Stanford, James McMurphy (*7* H. M. G.); Alma and Guadaloupe, H. E. Parks, **type** of *Geopora glabra* Gilkey (*215* H. M. G.); Frances Simes Hastings Nat. Hist. Reserv., Monterey, J. M. Linsdale (*367, 375, 381, 382, 392* H. M. G.).

OREGON: Corvallis, S. M. Zeller (*253* H. M. G.).

KEY TO AMERICAN SPECIES OF HYDNOTRYA

Spores essentially globose, any elongation occurring in the epispore, only.
  Thickening of epispore giving cubical appearance, especially to terminal spore...*H. cubispora*
  Thickening of epispore in form of a few coarse rounded protuberances, not giving cubical appearance to spore..................*H. carnea*
Spores ellipsoid.
  Spores not exceeding 20 µ in length, generally much shorter *H. ellipsospora*
  Spores 30 µ or more in length.
    Spore surface papillose............................*H. yukonensis*
    Spore surface lacuno-rugose.......................*H. variiformis*

Terfezia Longii sp. nov. (FIG. 17)

Ascomatibus subglobosis, ad 3.5 cm. diam., albidis, levibus · textis corticis compactis, crasse pseudoparenchymaticis et prosenchymaticis; ascis multis, subglobosis ad fere cylindricis 60–80 µ; sporis globosis, 20–26 µ, pallidis, reticulatis spinosis.

Ascocarp subglobose, reaching 3.5 cm. in diam., whitish, smooth; cortex consisting principally of coarse pseudoparenchyma and prosenchyma, with occasional irregularly placed large hyphae; sterile "tissue" of gleba looser, principally hyphal and, upon drying, tending to shrink more conspicuously than cortex; walls of all cells thin and delicate; asci globose to somewhat elongate, small, averaging 60–80 µ in length, inconspicuous, not readily separable from glebal "tissue," generally closely packed with spores; spores 20–24 µ (including spines), coarsely alveolate, with generally slender spines at angles of alveoli; number of spines on circumference averaging 15 or fewer.

NEW MEXICO: Near Corono, W. H. Long and D. J. Stouffer *9740*, **type** (*283* H. M. G.).

T. Longii somewhat resembles, in general appearance, *T. spinosa* Hark. which was named in 1899 from specimens collected in Louisiana in 1886 and distributed by Ellis and Everhart under the name *T. Leonis* Tul. as No. *1782* (Sec. ser., Cent. XVIII). The intriguing possibility of linking the New Mexican material with this species, and heralding a new appearance of this long-lost *Terfezia*, failed after careful comparison revealed constant differences. These are recorded in the description of *T. spinosa* and the *Terfezia* key which follow.

The author takes pleasure in dedicating this new species to its discoverer, Dr. W. H. Long.

TERFEZIA SPINOSA Hark.

Proc. Calif. Acad. Sci., 3d ser. 1: *277* (1899). Distributed by Ellis and Everhart as *T. Leonis* Tul. (No. *1782*, Cent. XVIII).

Ascocarp subglobose, white or citron, smooth; cortex consisting of both tangled and parallel hyphae, with areas of pseudoparenchyma; sterile "tissue" of gleba principally of closely tangled hyphae as compact as cortex and not inclined to shrink more perceptibly than cortex upon drying; asci many, subglobose to (often) long and narrow, averaging 100–120 μ in length, conspicuous, readily separable from glebal "tissue," spores loosely arranged within; spores 24–28 μ (including spines), spinose, the spines sometimes slender or more often blunt and broadened at base, the bases often anastomosing over surface of spore, sometimes forming an irregular interrupted incomplete alveolation; number of spines on circumference averaging 20 or more.

LOUISIANA: Red River Valley near Natchitoches, E. Forges, **type** (*108ª* Hk. Col., Stanford; *271* H. M. G.).

TERFEZIA GIGANTEA Imai (FIGS. 15–16)

Proc. Imp. Acad. **IX**: 4, 1933.

In 1939, Dr. L. O. Overholts discovered on a "mossy bank by a stream" in Center County, Pennsylvania, a large hypogaeous fungus which proved to be a *Terfezia*, the third species of this genus taken in America. Upon the single ascocarp found, the following description is based:

Ascocarp 5 × 5.5 cm. in diam., surface nearly smooth but marked off, apparently by cracking of thin superficial layer, into low polygonal areas, these more pronounced upon drying; surface of dried specimen terra cotta (R.) to burnt umber (R.), probably paler when fresh, with evidence of early tomentum; cortex-like outer sterile area 800 μ or more thick, superficial cells variable, some forming knotted hairs of tomentum; subsurface layer coarsely pseudoparenchymatous, changing gradually to smaller-celled prosenchyma and loose hyphal structure of fertile interiors; asci nearly globose, 100–120 μ in diam.; spores globose, 44–52 μ, aniline yellow (R.), minutely roughened by more or less coalescent granules or by obscure alveolation, epispore 3–4 μ thick.

PENNSYLVANIA: Reitz Gap, Center Co., L. O. Overholts, *22168* (*310* H. M. G.).

With considerable hesitation, this species is identified with *T. gigantea,* named in 1933 by Dr. Sanshi Imai, from specimens in the forests of Hokkaido, Prov. Ishikari, Japan. In general characters it agrees with that species as described, particularly in the very large minutely-sculptured spores. In our specimen, the spores average definitely larger and are distinctly roughened but not "covered with minute spines" as described and figured for the Japanese species. However, such minute sculpturing is interpreted with difficulty, and may be modified by various factors such as degree of spore maturity.

Imai does not mention a tomentum, of which traces are found on the ascocarp here considered; but, being evanescent, it may easily be overlooked. Neither are the low polygonal areas noted, which are conspicuous on our specimen; though these are suggested by Dr. Imai's illustration, and by his description of the ascocarp surface as "rough, with often evident and large crackings."

When comparison with authentic material of *T. giganteum* becomes possible, our specimen may prove sufficiently distinct to merit a new specific epithet; but at present it seems wiser to include it under this large-spored species already established.

KEY TO TERFEZIA SPECIES KNOWN IN AMERICA

Spores 44–52 μ, minutely roughened........................*T. gigantea*
Spores less than 30 μ.
    Spores coarsely and regularly alveolate and spinose, crowded in small inconspicuous asci....................................*T. Longii*
    Spores spinose, spines irregularly anastomosing at base; spores loosely arranged in large conspicuous asci......................*T. spinosa*

EXTENSIONS OF RANGE SINCE THE PUBLICATION, IN 1939, OF TUBERALES OF NORTH AMERICA

Barssia oregonensis Gilkey. OREGON: Langdon Lake, Blue Mts., S. M. Zeller (*300* H. M. G.); Roaring River, Linn Co., Lee Powell (*320* H. M. G.).

Genea arenaria Hk. CALIFORNIA: Monterey, Blomquist and Linsdale (*359, 368–9, 374, 384, 386, 394, 399* H. M. G.).

Genea cerebriformis (Hk.) Gilkey. CALIFORNIA: Monterey, Blomquist and Linsdale (*387* H. M. G.). OREGON: Clackamas Co., A. M. and D. P. Rogers (*324–7* H. M. G.).

Genea Gardneri Gilkey. CALIFORNIA: Monterey, Blomquist and Linsdale (*371, 373* H. M. G.).

Genea Harknessii Gilkey. OREGON: Clackamas Co., A. M. Rogers, H. M. Gilkey (*328* H. M. G.).

Genea intermedia Gilkey. CALIFORNIA: Monterey, Blomquist and Linsdale (*360, 385, 389, 400, 401,* H. M. G.).

Geopora Harknessii Fischer. OREGON: Oregon State College Campus, Corvallis, Maxwell Doty (*305* H. M. G.).

Geopora magnata Hk. CALIFORNIA: Pasadena, A. G. Barr (*279* H. M. G.).

Hydnobolites californicus Fischer. CALIFORNIA: Monterey, Blomquist and Linsdale (*377, 379, 383, 393, 395* H. M. G.).

Hydnotrya cubispora (Bessey and Thompson) Gilkey. ALASKA: Ketchikan, Dale Parks (*306* H. M. G.). OREGON: Clatsop Co., E. and F. Smith (*315* H. M. G.); H. M. Gilkey (*316* H. M. G.); Reedsport, H. M. Gilkey (*225* H. M. G.). TENNESSEE: Great Smoky Mts., Dorothy M. Linder (*307* H. M. G.).

Picoa carthusiana Tul. OREGON: Saddle Mt., Clatsop Co., Elizabeth Smith (*319* H. M. G.).

Tuber californicum Hk. CALIFORNIA: Monterey, Blomquist and Linsdale (*388* H. M. G.). OREGON: Clackamas Co., A. M. and D. P. Rogers (*323* H. M. G.).

Tuber candidum Hk. CALIFORNIA: Monterey, Blomquist and Linsdale (*376, 402* H. M. G.).

Tuber dryophilum Tul. MICHIGAN: East Lansing, Forrest C. Strong (*405* H. M. G.).

OREGON STATE COLLEGE,
CORVALLIS, OREGON

EXPLANATION OF FIGURES

FIG. 1. *Caulocarpa montana*, upper view of ascocarp, × 1. FIG. 2. *Caulocarpa montana*, longitudinal section of ascocarp, × 1. FIG. 3. *Caulocarpa montana*, asci and paraphyses, × 400 diam. FIG. 4. *Caulocarpa montana*, spores, × 1000 diam. FIG. 5. *Hydnotrya variiformis*, simple ascocarp, × 1. FIG. 6. *Hydnotrya variiformis*, longitudinal section of simple ascocarp, × 1. FIG. 7. *Hydnotrya variiformis*, convoluted ascocarp, × 1. FIG. 8. *Hydnotrya variiformis*, longitudinal section of convoluted ascocarp, × 1. FIG. 9. *Hydnotrya variiformis*, spore, × 600 diam. FIG. 10. *Hydnotrya variiformis*, longitudinal section of spore, × 600 diam. FIG. 11. *Hydnotrya variiformis*, asci and paraphyses, × 400 diam. FIG. 12. *Hydnotrya yukonensis*, longitudinal section of spore, × 600 diam. FIG. 13. *Hydnotrya yukonensis*, one-half of spore, × 600 diam. FIG. 14. *Hydnotrya ellipsospora*, spore, × 1300 diam. FIG. 15. *Terfezia gigantea*, ascocarp, × ⅝ diam. FIG. 16. *Terfezia gigantea*, spore, × 500 diam. FIG. 17. *Terfezia longii*, spore, × 800 diam.

TAXONOMIC NOTES ON MYXOMYCETES. II

G. W. Martin

BADHAMIA MAGNA Peck

In his original description of *Dictydium magnum* (Ann. Rep. N. Y. State Mus. **24**: 84. 1872), Peck mentioned the reticulate walls of the sporangia as one of the distinctive characters of the species. Later (Ann. Rep. N. Y. State Mus. **31**: 57. 1879), in transferring the species to *Badhamia*, he emphasized that character, stating that when it is taken into account with the large size and the globose sporangia, the species may readily be separated from forms of *B. utricularis*. A. Lister (Mycetozoa p. 33. **1894**) stated that it is nearly allied to *B. hyalina*. Sturgis (Trans. Conn. Acad. Arts & Sci. **10**: 466. 1900) re-examined Peck's type and redescribed and illustrated it, deciding that although closely related to *B. utricularis*, it might be regarded "for the present" as distinct. G. Lister (Mycetozoa ed. 3, p. 14. 1925) states that it is hardly more than a variety of *B. utricularis*. Macbride (N. A. Slime-Moulds p. 68. **1899**) assigned it provisionally to *B. capsulifera*. Later (N. A. Slime-Moulds ed. 2, p. 38. 1922), he recognized Peck's species. Macbride & Martin (Myxomycetes p. 31. **1934**) say "distinguished [from *B. utricularis*] by its unclustered, smoother spores and its long, slender, pale stipes." It is also noted that spores from the type collection are oval, umbonate and large and a reproduction of a camera lucida drawing of such a spore is shown on *pl. 2, fig. 26,* accompanied by a drawing from another specimen referred to the species, *fig. 25,* which is not significantly different from the spore of *B. utricularis* shown as *fig. 23* on the same plate. Hagelstein (Mycetozoa p. 20. **1944**) recognizes the species, distinguishing it from *B. utricularis* by the unclustered spores, the more robust sporangia on longer stalks and the darker, more minutely spinulose spores. In his key, he groups *B. utricularis* with the species having clustered spores, and *B. magna* with those having free spores, but in the text he admits that none of these characters is constant.

Re-examination of an extensive series of collections referred to these two species shows that neither the reticulate character of the peridium nor the long, pale stipes are dependable characters, each merging into the plain peridium and the sessile condition independently of the other. This leaves only the spore characters to consider. Since the spores in the original preparation from the type, preserved in glycerine on a slide, had become badly shrunken, another mount was made from the single cluster which constitutes our portion of the type collection. In this mount, the spores were nearly all spherical, 12 μ in diameter. A number were umbonate, but this character was not as conspicuous as in the previous mount. The only explanation I can suggest for this discrepancy is that the earlier mount was from a portion of a sporangium improperly matured. The spores themselves were no darker, and certainly no smoother than many collections clearly representing *B. utricularis*. Furthermore, the spore clusters supposed to characterize the latter species are by no means always in evidence. We have examples of that species determined by a number of competent students, including A. Lister, in which the spores are wholly free.

Since none of the characters ordinarily supposed to distinguish *B. magna* from *B. utricularis* is constant, I am convinced that Peck's species should be regarded as a synonym of *B. utricularis*.

CRIBRARIA ATROFUSCA Martin & Lovejoy

In the original description of this species (Jour. Wash. Acad. Sci. **22**: 92. 1932), the dark color of the sporangium and spores and the concentric granular rings on the inside of the calyculus are stressed. Hagelstein (Mycetozoa p. 190. **1944**) unites the species with *C. piriformis*. Re-examination of the collections cited in the description and of several additional collections, all from Colorado, confirm the original description in most essentials. The statement that the concentric granular thickenings are deposited on the inside of the cup is, however, misleading. The thickenings take the form of concentric corrugations clearly visible under a good lens on both the outside and the inside of the cup, in marked contrast with *C. piriformis,* in which the calyculus is distinctly ribbed. It is true that occasional collections of *C. piriformis* are nearly as dark as *C. atrofusca.* Schrader, in his original description, noted the change from blackish purple to brown in maturation. But dark forms of *C. piriformis* show evidence of premature drying, which is not the case in the specimens of *C. atrofusca.* In addition to the dark color and the concentric corrugations on the cup, the spores of *C. atrofusca* are dark reddish brown in mass and grayish brown by transmitted light whereas those of *piriformis* are yellow brown in mass, paler by transmitted light. and slightly smaller.

CRIBRARIA DICTYOSPORA Martin & Lovejoy

As originally described (Jour. Wash. Acad. Sci. 22: 91. 1932) the distinctive characters of this species were the dark color and the reticulate spores. Hagelstein (Mycetozoa p. 191. **1944**) accepts the species with some reservation, stating categorically that the spores are not reticulate and suggesting that it may be merely a dark phase of *C. piriformis.* Re-examination of the type and co-type shows the reticulation on the spores to be exactly as described in the original publication. The reticulations may be seen under a dry lens; the oil immersion lens brings them out very sharply. Recently a box containing twenty-four undetermined collections of *Cribraria* from Oregon was found among the material put aside by Dr. Macbride for later study. They almost certainly represent specimens sent to him many years ago by Prof. Morton E. Peck. Of the twenty-four, ten are referable to *C. dictyospora.* All ten show the spore reticulations clearly. Two other collections, also from Oregon, which had been determined as other species, also belong here. In view of the abundant material now available, there can be little doubt that *C. dictyospora* is a valid species.

DIDERMA COR-RUBRUM Macbr.

This species was based (N. A. Slime-Moulds ed. 2 p. 140. 1922) on a single Iowa collection. The entire collection was sent to England for examination and is now in the British Museum. After examining it, G. Lister (Mycetozoa ed. 3, p. 84. 1925) decided that it was an imperfect development of *D. montanum* and included it in the synonymy of that species. Later (Jour. Bot. **75**: 327. 1937), she recognized Macbride's species as valid and reported a collection from Kenya. Hagelstein (Mycetozoa p. 93. 1944) follows the earlier disposition in the third edition of the Mycetozoa, possibly having overlooked the later reference. Under *D. Lyallii* (p. 100) he records a collection of that species from Kansas. It seems highly probable that this report is based on T. E. Brooks' No. *641*, a portion of which is in the University of Iowa collection. Except for its rather pale, grayish purple columella, this collection agrees very satisfactorily with the original description of *D. cor-rubrum*, and with G. Lister's later comment on the species. It is quite distinct from either *D. montanum* or *D. Lyallii.* If the description of *D. cor-rubrum* is modified to permit such variation in the color of the columella as occurs in other species, the Kansas collection could be included satisfactorily there, and nowhere else.

DIDERMA LYALLII (Massee) Macbr.

Both Lister and Macbride and Martin place this species in *Eudiderma* on the basis of the calcareous outer wall. Lister describes the spores as "dark purplish brown rather coarsely warted, 10–15 μ"; Macbride and Martin say: "dark brown, rough, 14–17 μ." Meylan (Bull. Soc. Bot. Geneva II. 2: 262. 1910) places the species in the sub-genus *Leangium,* describing the spores as strongly papillate, 13–17 μ in diameter. Receipt of a collection from Mt. Shasta (W. B. Cooke *16670*) with striking spores, characterized by sparsely scattered, long, dark spines, has been the occasion for a re-examination of our material. If the two divisions of *Diderma* are to be maintained, only a narrowly verbal distinction would place *D. Lyallii* in *Eudiderma.* In habit it suggests at sight *Leangium* and even the peridium, although undoubtedly more calcareous and fragile than in most Leangiums, is very like that of the cartilaginous species. None of the spore descriptions is adequate. In those collections which may be regarded as fully developed, the spores are very uniform, the body of the spore being about 15 μ in diameter, rarely under 14 μ or over 16 μ. The spines, which may reach 2 μ in length, if included, would, of course, modify these dimensions. In the Shasta collection they are somewhat more sparse than in previous collections studied, but essentially similar to several. Other collections, however, have the surface covered with numerous dark warts, as illustrated in fig. 191 in Macbride and Martin. There may be two species concerned, but it seems more probable that in this, as in other alpine species, the conditions of development may radically affect the surface of the spores as well as the sporangial characters.

The existence of *Lepidoderma*-like plates on the peridium of a Rumanian collection has been noted (Macbride and Martin p. 128). In the Shasta collection, similar plates, distinctly crystalline, occur on the substratum, presumably secreted by the hypothallus.

DIDYMIUM SERPULA Fries

Didymium complanatum (Batsch) Rost. (Mon. p. 151. **1874**) is based on *Lycoperdon complanatum* Batsch (Elench. Fung. Cont. **1**: 251, *pl. 29, fig. a–c.* 1786). Rostafinski cites *D. Serpula* Fries (Syst. Myc. **3**: 126. 1829) as a synonym. Rostafinski's combination is, however, a later homonym of *D. complanatum* Schrad. (Nov. Gen. Pl. p. 24, *pl. 5, fig. 5.* **1797**) and *D. complanatum* Fuckel (Symb. Myc. **1**: 341. 1870). Neither Schrader's description nor his figure makes it possible to be sure to what his name applies. Rostafinski cites it as a synonym of his *D. confluens* which in its turn is generally regarded as a synonym of *D. crustaceum* Fries, but G. Lister (Mycetozoa ed. **2**, p. 129. 1911) cites it as a doubtful synonym of *D. melanospermum* (Pers.) Macbr. There seems to be no doubt that Fuckel's name is a synonym of *Diderma radiatum* (L.) Morgan. DeBary (Mycetozoen, *pl. 2, fig. 9–16.* **1864**) refers to *D. Serpula* Fries and his figure *15* leaves no doubt as to the species he was studying. Rostafinski himself (Mon. App. p. 21. 1876) substituted *D. Serpula* Fries for *D. complanatum* Rost. and cites his illustrations, *pl. 9, fig. 166, 180,* as representing it. A. Lister (Mycetozoa p. 96. 1899) used the epithet *Serpula,* but G. Lister (Mycetozoa ed. 2, p. 127. 1911) reverts to *complanatum* on the ground that "no writers before Rostafinski make any mention of the characteristic vesicles of the capillitium," overlooking deBary's clear description.

Certainly *D. complanatum* Rost. is not valid. Rather than coin a new name, it seems desirable to accept the species of Fries in the sense in which DeBary interpreted it, and Rostafinski, on maturer thought, applied it.

ENTERIDIUM MINUTUM Sturgis

Of the five currently recognized species of *Enteridium*, the common *E. Rozeanum* is readily recognized by its ferruginous colors and its incompletely reticulate spores. *E. yabeanum*, known only from Japan, is darker, but is also said to have completely free spores which are uniformly warted and smaller than those of any other species. The remaining three species are reported as having their spores borne habitually in clusters, or rarely free. Of these, only *E. olivaceum* may be said to be satisfactorily established. *E. liceoides* was originally described by A. Lister (Jour. Bot. **34**: 211. 1896) as a variety of *olivaceum* differing from the species only in its small size and plasmodiocarpous habit. It was later raised to specific rank by G. Lister (Guide Brit. Mycet. ed. **4**, p. 48. 1919). The last-named reference is not available to me, but neither in the original description of the variety nor in the discussion in the latest edition of the Lister monograph (ed. **3**, p. 194. 1925) is there convincing evidence that it is more than a small, dark, growth-form of *E. olivaceum* with depauperate pseudocapillitium. *E. minutum* Sturgis (Mycologia **9**: 329. 1917) is described as very small, the aethalia 1.5–2 mm. in diameter, with a pale yellow wall and with the spores in small clusters of two or three and yellow in mass. Sturgis described it as new with much hesitation and only after consultation with Miss Lister, but nevertheless in the third edition of the Mycetozoa the latter remarks that it is doubtful if *E. minutum* is more than a small form of *E. olivaceum*. In the 1896 paper cited, A. Lister had commented on the occurrence of *E. olivaceum* with free spores and in both the key and the description of the latter species in the Mycetozoa it is stated that the spores are sometimes free. In Macbride and Martin (Myxomycetes p. 236. **1934**) the distinction between free and clustered spores is given as the first character in the key to *Enteridium* to separate the two groups of species, and no allowance is made for free spores in *E. olivaceum.* This was in accordance with the material available for study at the time the key was written. Since then, much new material has come to hand and it appears that the description of that species must be modified. Of particular interest are several collections from Mt. Shasta, California, at an altitude of 8000 feet, communicated by Mr. W. B. Cooke. His No. *10263* consists of numerous fructifications, most of them rather small, varying from typical aethalia of the *olivaceum* type to plasmodiocarps of the *liceoides* type and small pulvinate structures of the *minutum* type. The spores are entirely free and vary from globose and 13–14 μ in diameter to oval and about 15 × 11 μ. Another specimen from Mt. Rainier, Washington, collected at 7000 feet by Dr. H. C. Greene, consists of a single broad, flat aethalium 9 cm. long and 1–2 cm. in width with the spores in small, loose clusters, mostly of twos or threes, with spines on the exposed surfaces only and 14–15 μ in diameter. It differs from what has been regarded as typical *E. olivaceum* only in the large aethalium and the large spores in small clusters. I conclude, therefore, that *E. liceoides* is a definite synonym of *E. olivaceum* and that *E. minutum* is in all probability nothing more than a small form of the same species. *E. Roszcanum* is, of course, quite distinct and *E. yabeanum,* so far as can be judged from the description, equally so.

LYCOGALA EXIGUUM Morgan

The characters stressed by Morgan (Jour. Cin. Soc. Nat. Hist. **15**: 134. 1893) in establishing this species were the small size, the dark color, the rather slender threads of the pseudocapillitium and the reticulate surface pattern made by the dark scales on the cortex. Of several specimens collected or determined by Morgan now in the University of Iowa collection, one, collected in Ohio in 1893, is in all probability part of the type. The scales of this specimen, when examined under the microscope, show the characteristic tessellate appearance which is the distinctive basis on which *L. epidendrum* var. *tessellatum* Lister (*in* Penzig, Myx. Buit. p. 77. 1898) was established. The spores are 5.5–6 μ in diameter, marked with faint warts and lines forming a very incomplete reticulate pattern on the surface, quite different from those of typical *L.*

epidendrum in which the spores are larger and the reticulation is complete or nearly so and is visible under a dry lens as the hyaline rim characteristic of reticulate spores in general. The tessellate character of the scales shows a wide range of variation and is not always evident, but the small, dark fructifications with dark, scale-like warts, slender pseudocapillitium and the characteristic spores justify recognition of *L. exiguum* as a valid species. *L. epidendrum* var. *tessellatum* Lister is a synonym. Of the specimens in the University of Iowa collection determined as *L. epidendrum* var. *exiguum,* a few are merely small, dark fruitings of *L. epidendrum.* The majority are *L. exiguum.* All specimens sent as *L. epidendrum* var. *tessellatum,* including Hagelstein's No. *13332,* also represent *L. exiguum.*

Oligonema Schweinitzii (Berk.) comb. nov.

Oligonema nitens (Lib.) Rost. is based on *Trichia nitens* Lib. (Pl. Crypt. Ard. Fasc. 3: *277.* 1834). *T. nitens* Lib. is, however, a homonym of *T. nitens* Pers. (Obs. Myc. 1: 62. 1796). Persoon cites *Lycoperdon favogineum* Batsch 1786 and *Stemonitis favoginea* Gmel. 1789 as synonyms of his species. All three names are universally recognized as synonyms of *Trichia favoginea* Pers. 1794, although this combination is not mentioned in the *Observationes.* The specific epithet *nitens* has been universally accepted for the *Oligonema* and is eminently appropriate, but unless some provision is made for the conservation of specific epithets, the disadvantages of which would, in my opinion, far outweigh its occasional convenience, the combination *O. nitens* is invalid and must be replaced by a combination employing the next available specific name. This appears to be provided by *Physarum Schweinitzii* Berk. (Grevillea 2: 66. 1873). Berkeley's name was given to a specimen which had been determined by Schweinitz as *Polyangium vitellinum* Link, now regarded as one of the Myxobacteriales. Whatever that name refers to, it does not come under consideration in this connection. Lister (Mycetozoa p. 174. 1894) states that "*Physarum Schweinitzii* Berk. [is] typical *O. nitens.*" The new combination here proposed is, therefore, in accord with the current rules of nomenclature.

PHYSARUM CONFERTUM Macbr.

No type is designated in the original description (N. A. Slime-Moulds ed. 2, p. 64. 1922). In the University of Iowa herbarium, there are several specimens of this species which were studied by Macbride. Three small boxes, apparently all parts of the same collection, and labelled in Macbride's hand *Physarum confertum,* contain perhaps the most representative material. One is marked "N. C." All are on dead leaves of some ericaceous plant. The best of these is designated as the type, and the type locality is North Carolina.

Physarum stellatum (Massee) comb. nov.

According to A. Lister (Mycetozoa p. 45. **1894**), the type specimen of *Lepidoderma stellatum* Massee (Grevillea **17**: 60. 1889) is "a fine specimen of *Physarum compactum.*" This comment is repeated by G. Lister in the second edition of the monograph. In the third edition (p. 32) she adopts the name *P. columbinum* (Rost.) Sturgis for the species, noting that the type specimen of *Lepidoderma stellatum* Massee is "a fine specimen" of the species. But *P. compactum* A. Lister and *P. columbinum* Sturgis are both later homonyms, the one of *P. compactum* Ehrenb. 1818, the other of *P. columbinum* Pers. 1795. Noting this, Macbride (N. A. Slime-Moulds ed. 2, p. 72. 1922) proposed the new name *Physarum Wingatense* for the species. This name was adopted by Macbride and Martin (Myxomycetes p. 69. **1934**) and by Hagelstein (Mycetozoa p. 40. **1944**). In view of the availability of Massee's earlier specific epithet, Macbride's name is untenable.

Tubifera microsperma (Berk. & Curt.) comb. nov.

Tubifera stipitata (Berk. & Rav.) Macbr. (N. A. Slime-Moulds p. 157. 1899) is based on *Licea stipitata* Berk. & Rav. *ex* Berk. & Curt. (Proc. Am. Acad. Arts. & Sci. **4**: 125. 1859), which, however, is a later homonym of *Licea stipitata* DC. (Fl. Fr. **6**: 101. 1815) which, in turn, is a synonym of *Didymium squamulosum* (Alb. & Schw.) Fries. *Licea microsperma* Berk. & Curt. (Grevillea **2**: 68. 1873) is cited by Massee (Mon. p. 40. **1892**) as a synonym of *Tubulina cylindrica* Rost., *i.e., Tubifera ferru-*

ginosa (Batsch) Gmel., "from exam. of type" and this is followed by G. Lister in the second edition of the Mycetozoa (1911, p. 192). In the third edition, however (1925, p. 188), she enters it as a synonym of *T. stipitata,* without comment. It seems reasonable to assume that so careful a student would not have made the change without adequate reason, particularly as the type collection was accessible to her. The inadequate and unsatisfactory original description, so far as it goes, suggests that it refers to the small-spored species. Certainly, *Tubifera stipitata* is invalid. On the basis of Lister's synonymy, *Licea microsperma* furnishes the earliest valid specific epithet which may be applied to the species.

STATE UNIVERSITY OF IOWA,
IOWA CITY

STUDIES ON SOME FUNGI FROM NORTHWESTERN WYOMING.[1]

IV. MISCELLANEOUS

LEWIS E. WEHMEYER

(WITH 2 FIGURES)

The previous papers of this series (19) were concerned with the Pyrenomycetes and Fungi Imperfecti which were collected by the writer during the summer of 1940. A general account of the area and of specific localities in which these collections were obtained will be found in the first paper. The present paper lists the fungi of the groups not previously treated, chiefly the Uredinales and Discomycetes.

The rusts are abundant on a wide variety of hosts in this region. Most of the species collected have been previously reported from the Northwest. Many fleshy fungi and Discomycetes also occur in this area but their occurrence is very sporadic, depending upon the local and occasional rains, or upon other sources of moisture as springs, moist creek beds and the like. Most of the fungi of this type were collected upon two occasions, in Indian Paint Brush Canyon in the Teton National Park and at the Hoback Canyon Forest Camp, as can be seen from the localities cited. Both of these collecting trips were made into these localities a few days after one of the heavy local showers of late summer. Dr. A. H. Smith has kindly determined the Agaricaceae.

EXOASCACEAE

TAPHRINA ALPINA Johans.

Causing a profusely branching "witches-broom" growth, the leaves of which turn yellowish to brown. Hymenium on the underside of the leaf but showing no superficial indication of its presence, even under a lens. Ascogenous cells thick-walled, hyaline, 10–18 × 9–10 μ, forming a network just beneath the epidermis, or occasionally rupturing this tissue. Asci mostly hypophyllous, small, 21–27 × 8.5–9.5 µ. Ascospores globose, 3.5–5 µ in diameter.

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[1] Papers from the Department of Botany of the University of Michigan No. 844.

Camp Davis: on *Betula glandulosa* Michx., July (*1259*).

This material was sent to W. W. Ray for examination and the following quotation from his conclusions (*in litt.*) agrees in all respects with those reached by the writer: "In reading over the description of *T. alpina* and *T. nana,* there is little to separate them and it may well be they are really the same. . . . On the basis of the position of the majority of the asci (hypophyllous) and the frequent occurrence of insertion of the basal cells between the epidermal cells, I am inclined to call the collection *T. alpina.*"

DISCOMYCETES

HETEROSPHAERIA LINARIAE (Rab.) Rehm

Glory Mt.: on *Linaria vulgaris* Mill., June 20 (*1023*).

The spores of this collection are pyriform to clavate, one celled, hyaline and 10(–12) × 3.5–5 µ. They may be somewhat immature, but are slightly smaller than the spore measurements given for *H. Linariae* (9–14 × 3–4 µ), and are more nearly like those of *H. Patella* var. *Lojkae* Rehm, reported from the high Alps, with small clavate spores (9–12 × 2.5–3 µ). The small apothecia (500–800 µ in diameter) and the occurrence on *Linaria,* on the other hand, suggest this species.

The conidial stage of species of *Heterosphaeria* has been reported as consisting of lunate, fusoid, often appendaged conidia, borne in pycnidia similar in appearance to the young enclosed apothecium. Tulasne (**17**, p. 176) and others report that conidia may even be mixed in with the ascus hymenium. Brefeld (**2**, **10**: 182–87) reports such lunate conidia and also ellipsoidal "microconidia" from ascospore cultures of *Heterosphaeria* spp. These pycnidial stages have been referred to the genus *Heteropatella,* which Fuckel (**7**) described as a Discomycete without ascospores. His *H. lacera,* with conidia one-celled, curved, appendaged, and with an overall length of 64–72 µ, is given as the conidial stage of *Heterosphaeria Linariae.* The conidia of *H. Patella* are given by Tulasne as 25–30 × 3.5 µ and one-celled but becoming septate upon germination.

As previously pointed out (19, II) *Heteropatella umbilicata* (Pers) Jaap is very common on many hosts at high altitudes in Wyoming In no case, however, was the ascus stage of a *Heterosphaeria* found on any of these collections, and no *Heteropatella* pycnidia or conidia were found associated with this collection of *Heterosphaeria Linariae* Rehm (14) states that *Heterosphaeria Patella* is seldom found in the ascus stage, although the conidial stage is common It is possible that *Heteropatella umbilicata,* which has conidia more like those of *Heterosphaeria Patella,* is the conidial stage of this or a similar species

Karschia adnata Kanouse sp nov * (FIG 1–2)

Apothecia dispersa, superficialia, sessilia, late adfixa, 250–750 μ diametro, convexa, glabra vel modice aspera, atra, marginata, si umida mollia, cerea, superficie inferiore grisei-brunnea, margine concoloria Hypothecium tenue, pallidum, pseudoparenchymatosum, excipulo simili sed cellulis majoribus, pallide brunneis Asci crasse clavati, 6- vel 8-spori, 65–80 μ longi, 18–20 (25) μ crassi Sporae crasse ovoideae, variae, 18–22 (24) μ longae, 8–12 μ crassae, aurei-brunneae, uniseptatae, apice rotundatae, cellulis ambobus guttulatis, saepe inaequalibus Paraphyses numerosi, ramosi, apicibus clavatis vel subglobosis, atro-brunneis, supra ascos producti et epithecium brunneum densum formans Hymenium cum iodo nitide caeruleum

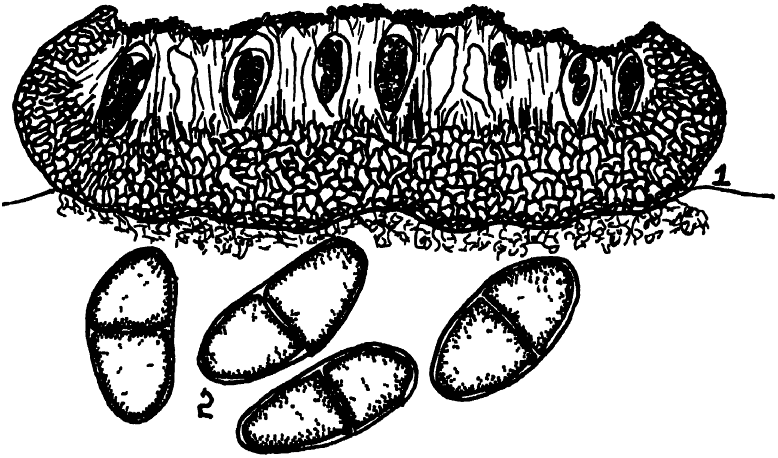

FIG 1 Section of apothecium of *Karschia adnata*
FIG 2 Ascospores of *Karschia adnata*

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* The writer is indebted to Dr B B Kanouse for the description and discussion of this species

Specimen typicum ex ligno coniferarum, in Hoback Canyon, Jackson, Wyoming, 16 Julii, 1940, legit L. E. Wehmeyer, sub numero *1154;* in Herb. Univ. Mich. conservatum.

Apothecia sessile, superficial, scattered or gregarious, broadly attached, convex when moist, 0.25–0.75 mm. in diameter, smooth to slightly roughened, soft-waxy when moist, black, marginate; margin grayish-tan, concolorous with the under surface, inconspicuous when wet; hypothecium thin, colorless, hyphal cells compacted into pseudoparenchymatic tissue, excipulum scarcely distinguishable from the hypothecium, cells slightly larger and colored faintly brown; asci broadly clavate, 65–80 × 18–20 (25) μ, 6–8 spored; spores broadly ovate-oblong, variable, frequently slightly constricted at the septum, golden brown, two-celled, cells frequently unequal in size, each cell containing an oil globule, the ends rounded or sometimes provided with a minute point, 18–22 (24) × 8–12 μ; paraphyses numerous, branched above one or more times, the apical cells clavate to subspherical, the upper portions colored dark brown, extending beyond the asci and forming a dense brown epithecium; the hymenium, excepting the spores, turns a brilliant blue in iodine.

On weathered coniferous wood, Hoback Canyon, Wyoming, July 17, 1940. L. E. Wehmeyer, No. *1154* (**type**). Additional collection, Hoback Canyon, July 16, L. E. Wehmeyer, No. *1148*. Type deposited in the Herbarium of the University of Michigan.

Of the many species of *Karschia* described on woody substrata, but few are reported lacking algal cells in their thalli. Butler (3) discusses but two such species, *K. lignyota* (Fr.) Sacc. and *K. stygia* (B. & C.) Massee. Our fungus differs from *K. lignyota*, on coniferous substrata, in having larger spores and lacking the yellow-green color in the hymenium, mentioned by Butler (3) for that species. *K. stygia* has not been reported on coniferous wood and differs from *K. adnata* in the narrow central attachment and red-brown hypothecial color of the apothecium and the conspicuous hexagonal cells in the excipulum. Velenovsky (18) described two species, *K. juniperi* and *K. microscopica*, growing on coniferous wood but the spores of both of these are smaller than those of *K. adnata*. *K. Sabinae* Rehm and *K. occidentalis* Earle, also reported on conifer wood, have been removed to other genera by Miss Butler (3).

A few groups of a one-celled alga were found in the hypothecia of some of the cups. There was no direct connection between the algae and the fungous hyphae, such as is seen in a lichen. They are believed to be merely inclusions and were seen more frequently in immature apothecia.

NAEVIA EPILOBII Karst.

South of Teton Pass: on *Epilobium angustifolium* L., July 11 (*1116b*).

The scattered, brownish-yellow apothecia are associated with those of *Pyrenopeziza compressula* on the same stems. The spores are immature, ellipsoid, one-celled, hyaline, and measure 14–19 × 6–7 μ. Nannfeldt (11, p. 191) says that this species belongs in his genus *Lactinaevia*.

PHRAGMONAEVIA EMERGENS (Karst.) Rehm

Elk Refuge, Jackson, Wyo., on *Juncus filiformis* L., July 1 (*1072c*).

Rehm (14) gives the spores of this species as narrow-clavate, pointed at one end, slightly curved, two- to four-celled and 12–21 × 1.5–2 μ. The spores of this collection are somewhat immature, fusoid, two-celled and 14–18 × 2.5–3.5 μ. Otherwise there is close agreement. Whether this difference in the spores is due to immaturity or is constant in this region can be determined only by the study of additional collections.

PYRENOPEZIZA COMPRESSULA Rehm

South of Teton Pass: on *Epilobium angustifolium* L., July 11 (*1116a*).

The apothecia appear as scattered black discs which, when young, are surrounded by a white halo caused by the raised blister of epidermis. The spores are one-celled, hyaline, slightly curved, cylindric to fusoid and 9–11.5 × 1.5–2 μ.

This collection agrees very well with the description of the above species, except for the gray-blue hymenium which was not seen in these young apothecia.

PYRENOPEZIZA CALIFORNICA Sacc.

Camp Davis: on *Linum Lewisii* Pursh, June 24 (*1047*).

This collection has slightly smaller apothecia (150–250 μ), narrower spores (12–13 × 2–2.5 μ) and broader asci (40–53 × 7–9 μ) than those originally given for this species, but these differences do not seem to be of specific significance.

HELVELLA CRISPA Fr.

Teton National Park: on damp mossy bank, Indian Paint Brush Canyon, July 30 (*1230*).

A very small specimen (1.5 cm. tall) of this species.

HUMARINA PURPUREA Seav.

Hoback Canyon: on mossy soil, Forest Camp, July 22 (*1222*).

The spores are hyaline to pale brown, finally slightly verrucose, with a large central guttula and 21–23 × 12–13 μ, which is somewhat larger than the measurements given by Seaver (13–20 × 8–10 μ).

LAMPROSPORA HAEMASTIGMA (Hedw.), Seav.

Hoback–Snake River Junction: on damp soil, July 17 (*1151*).

The spores (13–16 μ diam.) are somewhat smaller than given by Seaver (20 μ).

MORCHELLA ANGUSTICEPS Pk.

Teton National Park: on soil, moist creek bed, Cascade Canyon, June 27 (*1227*).

PATELLA SETOSA (Nees) Seav.

Hoback–Snake River Junction: on mossy decayed wood, July 17 (*1150*).

PEZIZA FIMETI (Fck.) Seav.

Hoback Forest Camp: on horse dung, July 22 (*1231*).

This species differs from *P. sylvestris* only in its habitat on dung.

PEZIZA REPANDA Pers.

Teton National Park: on damp soil, Indian Paint Brush Canyon, July 20 (*1225*).

PEZIZA SYLVESTRIS (Boud.) Sacc. & Trott.

Hoback Canyon: on moist humus, poplar thicket, July 3 (*1228*).

PSEUDOPLECTANIA NIGRELLA (Fr.) Fck.

Teton National Park: on damp soil, Indian Paint Brush Canyon, July 30 (*1226*).

PYRENOMYCETES

ERYSIPHE POLYGONI DC.
Hoback Canyon: on *Polygonum aviculare* L., Aug. 6 (*1203*).

SPHAEROTHECA PANNOSA (Wallr.) Lév.
South of Teton Pass: on *Geranium Parryi* (Engelm.) Heller, July 11 (*1270*).

UREDINALES

CHRYSOMYXA ARCTOSTAPHYLI Diet. Camp Davis: on *Arctostaphylos Uva-ursi* (L.) Spreng. (III), June 26 (*1057*).

COLEOSPORIUM SOLIDAGINIS (Schw.) Thuem. Camp Davis: on *Aster* sp. (III), July 4 (*1083*) and *Pinus contorta* Dougl. (I), July 5 (*1081*).

CRONARTIUM COMMANDRAE Pk. Camp Davis: on *Commandra pallida* A. DC. (II), June 18 (*1014*) and July 18 (*1156*) and (II & III), Aug. 2 (*1250*).

CUMMINSIELLA SANGUINEA (Pk.) Arth. Hoback Canyon: on *Mahonia aquifolium* (Pursh) Nutt. (O & I), July 3 (*1263*) and (II & III), June 25 (*1054*).

GYMNOSPORANGIUM JUVENESCENS Kern. Camp Davis: on *Amelanchier elliptica* A. Nels. (O & I), Aug. 6 (*1202*).

HYALOPSORA POLYPODII (Pers.) Magn. Hoback Canyon: on *Filix fragilis* (L.) Underw. (II), Red Creek, July 29 (*1182*).

MELAMPSORA ABIETI-CAPRAEARUM Tubeuf. Teton National Park: on *Salix* spp. (II), Cascade Canyon, June 27 (*1060*). Indian Paint Brush Canyon, July 30 (*1189*) and Phelps Lake, Aug. 5 (*1247*).

The measurements of the urediospores of these three collections are, respectively, 14–15 × 18–20; 12.5–14 × 15–18 and 12–16 × 14–20 μ. The thickness of the urediospore walls is 1.5–2.5; 1.5–1.7 and 2–3 μ. There is little to choose here between this species and *M. Ribesii-purpureae*. The thickness of the walls of the last collection suggests the latter species.

MELAMPSORA ALBERTENSIS Arth. Camp Davis: on *Pseudotsuga mucronata* (Raf.) Sudw. (I), June 25 (*1052*). Hoback Canyon: on *Pseudotsuga mucronata* (I), Forest Camp, July 3 (*1264*). Teton National Park: on *Populus tremuloides* Michx. (II), Indian Paint Brush Canyon, July 30 (*1190*) and Phelps Lake, Aug. 5 (*1248*).

MELAMPSORA BIGELOWII Thuem. Camp Davis: on *Salix* sp. (II), Aug. 2 (*1251*).

MELAMPSORA OCCIDENTALIS Jacks. Teton National Park: on *Populus angustifolia* James (II), Phelps Lake, Aug. 5 (*1207*). The urediospores of this collection were elongate ellipsoid, 30–40 × 16–21.5 μ, and their walls were 1.5–3.5 μ in thickness, or up to 5.5 μ at the thickest region.

MELAMPSORA LINI (Pers.) Lév. Camp Davis: on *Linum Lewisii* Pursh (II), June 24 (*1042*).

MELAMPSORELLA CERASTII (Pers.) Schroet. Granite Creek Hot Springs: on *Picea Engelmanni* (Parry) Englem. (O), June 23 (*1037*) and *Abies lasiocarpa* (Hook.) Nutt. (I), Aug. 1 (*1195*).

PHRAGMIDIUM IVESIAE Syd. Camp Davis: on *Potentilla viridescens* Rydb. (II & III), June 25 (*1049*) and *P. pectinisecta* Rydb (II & III), June 23 (*1050*).

PHRAGMIDIUM MONTIVAGUM Arth. Camp Davis: on *Rosa* sp. (III), July 18 (*1157*). Dr. G. B. Cummins, to whom material of this collection was sent, comments (*in litt.*): "No. *1157* is probably *P. montivagum* but might be *P. Rosae-arkansanae,* the teliospores and pedicels agree better with the latter but the species is not a mountain species."

PHRAGMIDIUM OCCIDENTALE Arth. Hoback Canyon: Red Creek, on *Rubus parviflorus* Nutt. (I), July 18 (*1268*) and (I & III) July 29 (*1178*). Teton National Park: on *Rubus parviflorus* (I), Jenny Lake, June 27 (*1058*) and (III), Phelps Lake, Aug. 5 (*1249*).

PHRAGMIDIUM ROSAE-ACICULARIS Liro. Hoback Canyon: on *Rosa* sp. (III), Red Creek, July 29 (*1179*), *fide* G. B. Cummins.

PHRAGMIDIUM RUBI-IDAEI (DC.) Karst. Teton National Park: on *Rubus strigosus* Michx. (I), Jenny Lake, June 27 (*1059*).

PUCCINIA ABSINTHII (Hedw. f.) DC. Camp Davis: on *Artemisia tridentata* Nutt. (II) on leaves, (III) on stems, July 13 (*1137*) and *A. cana* Pursh (III), Aug. 3 (*1200*). Hoback Canyon; on *A. tridentata* (II), July 16 (*1146*).

PUCCINIA ASTERIS Duby. Granite Creek Canyon: on *Aster* sp. (III), Aug. 1 (*1196*), *fide* E. B. Mains.

PUCCINIA ATROFUSCA (Dudl. & Thomp. Holw. Teton National Park: on *Artemisia ludoviciana* Nutt. (I), Death Canyon, Aug. 5 (*1205*).

PUCCINIA BALSAMORRHIZAE Peck. Camp Davis: on *Balsamorrhiza sagittata* (Pursh) Nutt. (II & III), July 1 (*1069*).

PUCCINIA CALOCHORTI Peck. Camp Davis: on *Calochortus Nuttallii* T. & G. (III), June 22 (*1039*).

PUCCINIA CARICIS var. URTICATA (Kern) Arth. Camp Davis: on *Urtica* sp. (I), June 22 (*1040*).

PUCCINIA CORONATA Cda. Camp Davis: on *Shepherdia canadensis* (L.) Nutt. (I), June 17 (*1018*).

PUCCINIA CRANDALLII Pam. & Hume. Camp Davis: on *Symphoricarpos pauciflorus* (Robbins) Britt. (I), June 17 (*1019*) and July (*1261*). Hoback Canyon: on *S. pauciflorus* (I), July 29 (*1267*).

PUCCINIA EXTENSICOLA var. HIERACIATA (Schw.) Arth. Camp Davis: on *Agoseris glauca* (Nutt.) Greene (I), June 17 (*1007*).

PUCCINIA EXTENSICOLA var. VALERIANAE Arth. Elk Refuge: on *Valeriana edulis* Nutt. (I), July 1 (*1070*). This material was examined by E. B. Mains and placed here rather than in *P. commutata,* because of the lack of uredia on infections with well advanced aecial pustules.

PUCCINIA GRINDELIAE Peck. Hoback Canyon: on *Erigeron salsuginosus* Gray (III), July 3 (*1077*) and *Aster Engelmannii* D.C.

Eat. (III), July 16 (*1147*). Teton National Park: on *Chrysopsis fulcrata* Greene (III), Aug. 5, Death Canyon (*1206*).

PUCCINIA HALENIAE Arth. & Holw. Skyline Trail: on *Gentiana calycosa* Griseb. (III), Overlook, Aug. 5 (*1204*).

PUCCINIA HEUCHERAE (Schw.) Diet. Hoback Canyon: on *Saxifraga arguta* Don (III), Red Creek, July 29 (*1183*).

PUCCINIA HIERACII (Schum.) Mart. Camp Davis: on *Hieracium* sp. (I), June 17 (*1005*); *Crepis acuminata* Nutt. (II & III), June 28 (*1038*) and *Taraxacum* sp. (II), July 29 (*1181*).

PUCCINIA HOLBOELLII (Hornem.) Rostr. Togwotee Pass: *Arabis canescens* Nutt. (III), July 8 (*1102*), elev. 11,000 ft.

PURRINIA JONESII var. TYPICA Arth. Teton Pass Road: on *Umbellifer* (*Cogswellia* sp.?) (I), June 20 (*1021*).

PUCCINIA MONOICA (Pk.) Arth. Togwotee Pass: *Smelowskia americana* Rydb. (I), July 8 (*1098*), elev. 10,500 ft.

PUCCINIA ONOPORDI Syd. Camp Davis: on *Onopordon Acanthium* L. (II), Aug. 1 (*1068*). This species is reported, in Arthur's Manual (1), only from Nova Scotia, and does not seem to have been previously reported from the West.

PUCCINIA PALMERI Diet. & Holw. Camp Davis: on *Pentstemon procerus* Dougl. (I), June 18 (*1013*).

PUCCINIA RUBIGO-VERA var. AGROPYRI (Erikss.) Arth. Camp Davis: on *Delphinium Brownii* Rydb. (I), June 22 (*1041*); *Thalictrum occidentale* Gray (I), June 17 (*1008*) and *Thalictrum* sp. (I), June 26 (*1266*). Cream Puff Mt.: on *Aquilegia coerulea* James (I), July 5 (*1087*). Hoback Canyon: on *Delphinium Brownii* (I), Granite Creek, July 29 (*1262*). South of Teton Pass: on *Clematis Douglassii* Hook. (I), July 11 (*1123*).

PUCCINIA RUBIGO-VERA var. AGROPYRINA (Erikss.) Arth. Camp Davis: on *Anemone cylindrica* Gray (I), June 18 (*1012*) and *A. globosa* Nutt. (I), June 22 (*1265*).

PUCCINIA RUBIGO-VERA var. APOCRYPTA (Ell. & Tr.) Arth. Hoback Canyon: on *Phacelia leucophylla* Torr. (I), June 25 (*1053*);

P. sericea (Graham) A. Gray (I), June 25 (*1051*). Teton Pass Road: on *Hydrophyllum capitatum* Dougl. (I), June 20 (*1034*).

PUCCINIA VAGANS (DC.) Arth. var. EPILOBII-TETRAGONI DC. Hoback Canyon: on *Epilobium* sp. (II & III), Aug. (*1252*), *fide* E. B. Mains.

PUCCINIASTRUM GOEPPERTIANUM (Kühn) Kleb. Teton National Park: on *Vaccinium scoparium* Leib. (III), Skyline Trail, July 24 (*1165*) and *V. membranaceum* Dougl. (III), Indian Paint Brush Canyon, July 30 (*1256*). Collections of the aecial stage on *Abies lasiocarpa* (Hook.) Nutt. from Cascade Canyon, Teton National Park (*1062*) and Hoback Forest Camp (*1260*) appear to be this species, but might be *P. pustulatum.*

PUCCINIASTRUM PUSTULATUM (Pers.) Diet. Hoback Canyon: on *Epilobium angustifolium* L. (II), July 17 (*1149*).

UROMYCES GLYCYRRHIZAE (Rab.) Magn. Snake River Canyon: on *Glycyrrhiza lepidota* Nutt. (III), July 15 (*1139*).

UROMYCES HEDYSARI-OBSCURI (DC.) Car. & Picc. Camp Davis: on *Hedysarum cinerascens* Rydb. (I), June 17 (*1010*). Hoback Canyon: on *Hedysarum* sp. (I, II & III), Granite Creek, Aug. 1 (*1192*). South of Teton Pass: on *Hedysarum* sp. (I), July 11 (*1125*).

UROMYCES PLUMBARIUS Peck. Gros Ventre River: on *Pachylophus caespitosus* (Nutt.) Raim. (III), July 19 (*1161*).

UROMYCES SOLIDAGINIS (Sommerf.) Niessl. Hoback Canyon: on *Solidago* sp. (III), Granite Creek, Aug. 1 (*1196*). These host leaves were originally designated as *Aster,* but are probably from a broad leaved species of *Solidago,* as the teliospores fit this species of *Uromyces* very well.

HYMENOMYCETES

Exobasidium Vaccinii (Fck.) Woron. Teton National Park: Indian Paint Brush Canyon, on *Menziesia ferruginea* Smith, July 30 (*1187*) and *Vaccinium membranaceum* Dougl., July 30 (*1257*).

Sarcodon imbricatus (L.) Karst. Teton National Park: on stream bank, Indian Paint Brush Canyon, July 30 (*1271*). *Fomes Pini* (Thore) Lloyd. Hoback Canyon: on conifer log, Red Creek, July 29 (*1273*). *Polyporus borealis* Fr. Teton National Park: on conifer log, Indian Paint Brush Canyon, July 30 (*1272*). *Coprinus ephermerus* Fr. Hoback Forest Camp: on horse dung, July 22 (*1235*). *Inocybe eutheles* (B. & Br.) Quél. Teton National Park: on mosses, Indian Paint Brush Canyon, July 30 (*1236*). *Inocybe rimosa sensu* Kauffman. Hoback-Snake-River-Junction, on moist bank, July 17 (*1237*). *Lactarius deliciosus* (Fr.) Quél. Hoback Forest Camp: under shrubs, July 22 (*1238*). *Lactarius Hibbardiae* Pk. Teton National Park: under spruce, Indian Paint Brush Canyon, July 30 (*1239*). *Panaeolus retirugis* (Fr.) Quél. Hoback Forest Camp: on horse dung, July 22 (*1240*). *Panaeolus semiovatus* (Fr.) Lundell. Hoback Forest Camp: on horse dung, July 22 (*1241*). *Pholiota squarrosa* (Fr.) Quél. Hoback Forest Camp: on rotten log, July 22 (*1242*). *Pleurotus striatulus* (Fr.) Quél. Hoback Canyon: on decayed conifer wood, July 17 (*1243*). *Psilocybe coprophila sensu* Ricken. Hoback Forest Camp: on horse dung, July 22 (*1244*). *Psilocybe sarcocephala* (Fr.) Gill. Hoback Forest Camp: on old wood, July 17 (*1245*) *Russula chamaeleontina sensu* Kauffman. Jackson, Wyo. (*1246*). *Stropharia semiglobata* (Fr.) Quél. var. *stercoraria*. Hoback Forest Camp: on horse dung, July 22 (*1234*).

FUNGI IMPERFECTI

A few collections of this group of fungi which have turned up since the earlier papers were published are considered here.

DIDYMARIA CONFERTA Syd.

This fungus forms angular brown areas between the smaller veins on both sides of the leaves. Two types of pustules, both arising from an interwoven knot of hyphae, are formed. In the case of the *Didymaria* pustules, the epidermis is widely ruptured and a dense fascicle of short stout conidiophores, 35–44 × 5–7 μ, is erumpent through it. These conidiophores bear oblong-ellipsoid, two-celled, hyaline conidia with a flattened basal scar and they measure 26–32(35) × 9–12.5 μ. The second type of pustule results from the formation of a spherical mass of hyphae with a definite outer dark brown wall and a radiate internal arrangement of hyphae. No spore formation was seen in any of these. They appear as minute black sclerotial dots, which may be either immature perithecia or pycnidia, and are very abundant in this material.

Hoback Canyon: Granite Creek, on *Wyethia amplexicaulis* Nutt., Aug. 1 (*1255*).

This fungus appears to be the same as that reported by Solheim (**15**, IV: 44) under this name, and upon examination of material sent him, Dr. Solheim (*in litt.*) states that they are identical and that his material also shows a few of the sclerotial bodies. This species was described (**16**, p. 186) from a collection by A. O. Garrett, on the same host, from Utah, and a later collection by Garrett (Fung. Col. *4723*) from the same host and locality is identical with the above collection and also shows a few sclerotial bodies.

In 1894, however, Ellis (**5**, p. 373) described a *Marsonia Wyethiae,* on *Wyethia glabra,* from California. An examination of type material (N.A.F. *3184*) of this species shows that it is very similar to if not merely a variety of *Didymaria conferta.* This *Marsonia* shows the same angular spots, but not the black sclerotial bodies. The acervuli are yellow-brown rather than pinkish-tan or grey, as in *D. conferta,* and the spores are shorter and more ovoid (20–23 × 10–13 μ). The spores in Fung. Col. *4723* are quite variable (18–27 × 10–13 μ), but generally more cylindric.

Didymaria is supposed to be one of the Moniliales, but these species have a definite basal stromatic cushion in the host. On the other hand they break through the epidermis freely and have freely exposed conidiophores. What is to determine the limits of these and neighboring genera, and thereby the proper binomial can only be decided by a comparative study of a large group of related species.

Cylindrosporium Umbelliferarum nom. nov.

Ascochyta Heraclei Lib. Exs. No. *51.*
Septoria Heraclei (Lib.) Desm. Pl. cr. Nord. d. Fr. No. *534.*
Cylindrosporium Heraclei E. & E. Journ. Myc. **4**: 52. 1888.
Cylindrosporium Heraclei (Lib.) Höhn. Sitz. Akad. Wiss. Wien **115**: 28. 1906.
Phloeochora Heraclei (Lib.) Höhn. Ber. deutsch. bot. Ges. **35**: 253. 1917.

Upper leaf surface only slightly differentiated or with numerous slightly discolored, small, angular areas, 1–2 mm. across, limited by the smaller veins. Under side of leaf with numerous small, flat, pulvinate, often confluent, black stromata, 200–800 µ in diameter and 150 µ thick.

Acervuli mostly epiphyllous, sometimes hypophyllous, arising as a thin stromatic layer, 400–800 µ in diameter, just beneath the epidermis. Hymenial layer of short fine conidiophores, causing a rupturing of the epidermis and a pushing out of a light colored mass of conidia, which are long, cylindric or somewhat tapered at the ends, more or less strongly curved, uniseptate, and 35–48 × 3.5 µ.

The stromata on the under surface are thickly scattered, dothideaceous, and composed of dark, thick-walled pseudoparenchyma. They rupture the epidermis and often show globose locular areas of lighter colored cells, but no asci or spores were seen. They appear to be the ascus stage of some dothideaceous fungus.

Hoback Canyon: on *Heracleum lanatum* Michx. Granite Creek, Aug. 1 (*1254*) and Forest Camp, July 22 (*1258*).

This fungus is the same as Ellis' *Cylindrosporium Heraclei* (4) (N.A.F. *3181*), of which he says "with *Phyllachora Heraclei* (Fr.)." Solheim (15, IV), in reporting this species, on *Ligusticum*, gives the conidia as 50–101 × 3–3.5 µ and says "The fungus is frequently associated with immature perithecial bodies." A collection made by Kauffman & Kanouse, at Centennial, Wyoming (Univ. Mich. Crypt. Herb.), shows similar stromatic bodies and acervuli. European collections (*i.e.* Krieger, Fung. Sax. *1597*) show an association of the same acervuli and conidia with similar stromatic bodies. Sydow's Myc. Germ. *1277*, of *C. Heraclei* (Lib.) Höhn., on *Pastinaca sativa*, on the other hand, shows this same type of acervulus and conidium, but no sclerotial bodies whatever. Although there is a good deal of variation in the size and character of the spots and acervuli and the size of the stromatic bodies and length of the conidia, there appears to be no correlation between these and the host or region. The spores all show the characteristic form and septation, and this association seems to be a widely distributed one on the Umbelliferae. Saccardo (Syll.

Fung. 2: 600) gives *Septoria Heraclei* (Lib.) Desm. as the spermogonial stage of *Phyllachora Heraclei* and Magnus (10) states that he has found the *Phyllachora* stage associated with Ellis' fungus, *C. Heraclei.*

There are a large number of conidial stages in the form genera *Cylindrosporium, Septogloeum, Ramularia, Phloeospora, Rhabdospora, Ascochyta,* etc., described on various species of the Umbelliferae, with conidia similar to those of this collection. There is so much ambiguity in the descriptions, however, that only an examination of authentic material can determine the true position of most of them. Höhnel (8), following Magnus (10), unites *Septoria Heraclei* (Lib.) Desm., *Cylindrosporium Heraclei* E. & E. and *C. hamatum* Bres. under the binomial *Cylindrosporium Heraclei* (Lib.) Höhn. In 1917, Höhnel (9) published a name, *Phloeochora,* which he applied to the conidial stages of species of *Phyllachora* (*Oligostroma*) occurring on Umbellifers. He gave the generic character merely as "Ähnlich *Phloeospora* aber phyllachoroid," and made the combination *P. Heraclei* (Lib.) Höhn. Even if this were considered a tenable generic description, it is obvious that his fungus is not like a *Phloeospora,* for it was separated from such forms by Magnus (10) who states that no *Septoria*-like forms were found in connection with *Phyllachora,* and Höhnel (8), himself, says of this fungus "Gehause fehlend." If this name is rejected, the fungus falls in *Cylindrosporium,* where it properly belongs. Unfortunately, however, both the binomials *Cylindrosporium Heraclei* (Lib.) Höhn. and *C. Heraclei* E. & E. (which becomes a synonym) are preceded by the prior *C. Heraclei* Oud. (12). Saccardo placed Oudemans' species as *Ramularia Heraclei* (Oud.) Sacc. Oudemans gave the spores as merely 12–25 × 4–5 μ. Saccardo gave them as 23–30 × 4–7 μ, fusoid, 1–3 septate and on long filiform conidiophore hyphae, 50–60 × 2–3 μ, which would indicate a different species from the one here discussed. It is necessary, therefore, to change the species name, and *C. umbelliferarum* is used. *Fusoma Heraclei* Oud. (13), with conidia 45–60 × 4 μ, finally septate and curved may be the same as *C. Umbelliferarum.*

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ANALYSIS OF PECK'S TYPES OF *MELIOLA BALSAMICOLA* AND *ASTERINA NUDA*

Glenn Gardner Hahn *

(WITH 2 FIGURES)

About sixteen years ago Gäumann (3) directed the attention of forest pathologists to a new and outstanding needle disease of Douglas-fir, *Pseudotsuga taxifolia* (Poir.) Britt. in Europe. In his announcement he suggested that the parasite involved might possibly be identical with an old fungus, *Adelopus balsamicola* (Peck) Theiss. (19, p. 482), an innocuous organism occurring commonly on the dead needles of balsam fir (*Abies balsamea* [L.] Mill.) in the United States. Gäumann (3, p. 66) stated the taxonomical problem as follows: "So far as the observations herein presented are concerned our fungus . . . is an ascomycete belonging to the genus *Adelopus.* According to our knowledge, a single species is known in this genus, namely, *Adelopus balsamicola* (Peck) Theiss. This species, which Wilson and Waldie (1928) investigated recently, was described originally in the year 1881 by Peck as *Meliola balsamicola* on the needles of *Abies balsamea* in the United States. Four years later Peck described the same fungus once more under the name *Asterina nuda.* Again eight years later the fungus was allocated by Ellis and Everhart to *Dimerosporium balsamicolum.* . . . Whether the form growing on Douglas-fir is identical with the original *A. balsamicola* growing on *Abies* needs demonstration by further research."

Following Gäumann's paper a considerable number of publications, all foreign, dealing with *Adelopus* appeared in the years preceding the outbreak of the war in 1939. Those by Plassmann (14), Steiner (17), and Rohde (15) particularly dealt with the taxonomic confusion of the organisms involved. Rohde recognized the Douglas-fir needle parasite definitely as a new species, which he called *Adelopus Gäumanni* in honor of the Swiss phytopathologist. At the same time he (15, pp. 495–498) analyzed the accumulated literature pertaining to the taxonomic relationship of the much discussed *Meliola balsamicola* (10) and *Asterina nuda* (11). For the first time this relationship appeared to be clarified correctly despite the fact that Rohde did not examine Peck's types.

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* Division of Forest Pathology, Bureau of Plant Industry, Soils, and Agricultural Engineering, in cooperation with the Osborn Botanical Laboratory, Yale University, New Haven, Conn.

In the study reported here, Peck's types and ten subsequent collections[1] relating to them have been examined. Some of the Albany material had been annotated by Dearness and two specimens had been determined by Saccardo. The writer also examined numerous fresh American specimens of Peck's *Asterina nuda*. In the main the writer's findings confirm Rohde's (15) conclusions; in addition, they present new and unpublished morphological data.

PECK'S TYPES AND OTHER HERBARIUM SPECIMENS

A study of Peck's types showed that *Meliola balsamicola* and *Asterina nuda* are two very distinct species. It confirmed Peck's (10, p. 52; 11, p. 102) original descriptions as well as his figures, which indicate definitely that Peck had intended originally to erect two species in two different genera.

MELIOLA BALSAMICOLA Pk. 1881

The label of the type packet carries the printed name, "*Asterina balsamicola* Pk.," a name that was never published. It is not known who printed this name. Although the collection date is not given, the year of collection according to a written communication from House (February 15, 1943) is the year for which the report is made. It appears that Peck did not date his collections

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[1] Through the courtesy of Dr. H. D. House, State Botanist, the writer was permitted to examine and study Peck's types and other related material deposited at the New York State Museum, Albany, N. Y.

FIG. 1. Peck's types, *Meliola balsamicola* and *Asterina nuda* on *Abies balsamea* needles. *A*, Perithecia of *M. balsamicola* on the upper surface of a needle associated with an apothecium of *Peziza balsamicola*. × 36. *B*, Perithecia of *A. nuda* arising from the stomata on the under side of the needle. × 36. *C*, Young subiculum of *M. balsamicola* showing coarse brown, applanate filaments on the upper side of the needle. × 36. *D*, Enlarged perithecia of *A. nuda*. × 72.

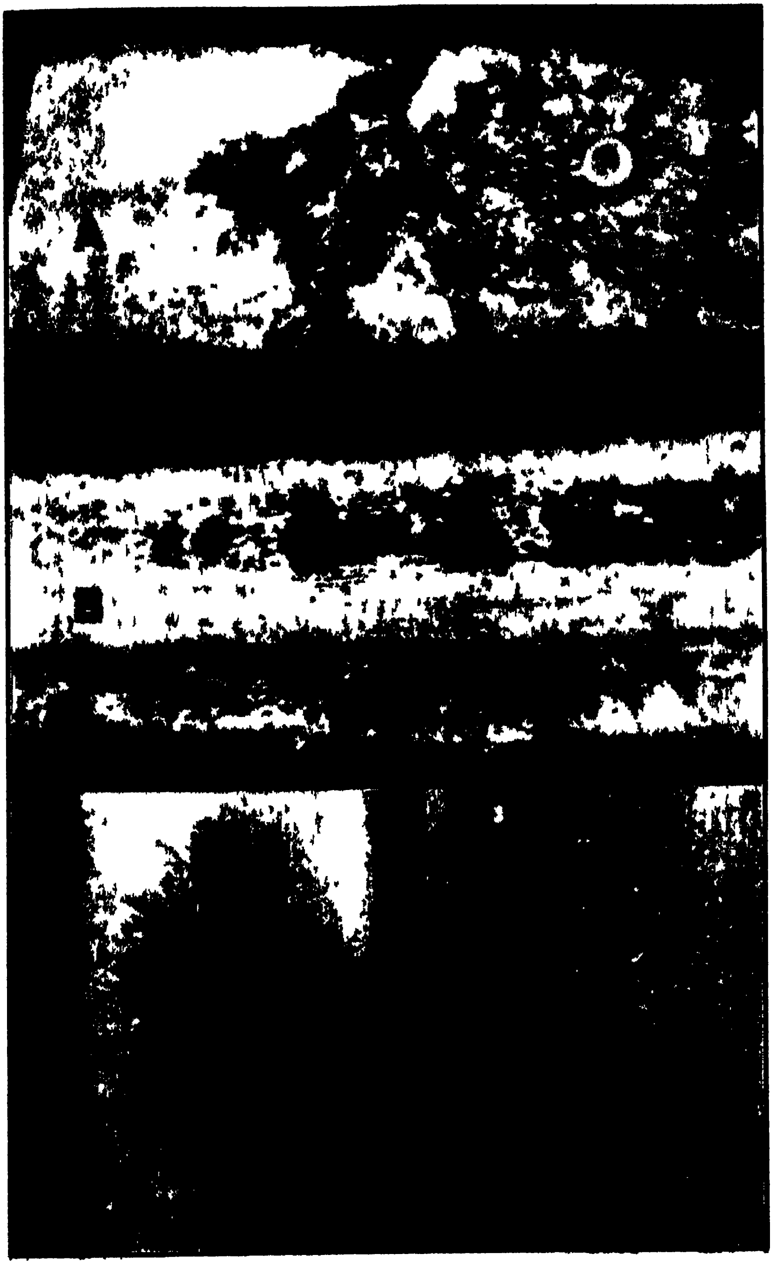

FIG 1

as a rule, and he rarely published a new species, except in his yearly report. In what appears to be Peck's handwriting the following data are also given: "Leg. Chas. H. Peck," and below "*Asterella*" and "(*Meliola balsamicola* Pk.)." The parentheses about *M. balsamicola* were very probably not placed there by Peck but by someone else. Apparently at the time Peck wrote the label in part, he was uncertain as to what he was going to call his fungus; however, he (10, p. 52) published it as *Meliola*.

The majority of the needles in the type collection show the *Meliola* described and illustrated by Peck (10, p. 52; Pl. I, FIGS. 23–27). As he pointed out the perithecia are exceedingly *few* in number (FIG. 1, *A*).[2] In this the species differs markedly from *Asterina nuda*, which produces an abundance of closely crowded fruiting bodies (FIG. 1, *B*; 15, FIG. 8). The writer observed the perithecia of *Meliola balsamicola* as being smooth, superficial, separate or clustered, blackish, ovate or subconical, mostly epiphyllous, less commonly hypophyllous, seated on an irregularly radiating, dark brownish, patchlike subiculum. This subiculum, which is very conspicuous, is at first applanate and filamentous (FIG. 1, *C*) but as the colony develops it becomes crustaceous (FIG. 1, *A*). In addition to differences in perithecial production (FIG. 1, *A, B*), the superficial subiculum sets off distinctly the *Meliola* from *A. nuda* with its intramatrical mycelial development. Rohde (15, p. 498) noted that in Peck's illustrations the perithecia of *M. balsamicola* are shown as being larger than those of *A. nuda*. Peck did not record measurements of perithecia for his species nor did the writer measure any in the type. A comparison of the fruiting bodies of the two species shown (FIG. 1) indicates that those of the *Meliola* are the larger, but Peck (10, Pl. 1, fig. 23) exaggerated their size in his illustration. The writer made no measurements of asci or of the bilocular ascospores. The spore size recorded by Peck of 9–11 μ has remained unaltered in the literature, although Saccardo referred the fungus without a new description to *Zukalia?* in 1891, and Ellis and Everhart placed it in *Dimerosporium* the following year. The writer observed that the ascospores recorded by Peck as being hyaline become fuligineous. Paraphyses were not reported by Peck nor were they observed by the writer.

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[2] The writer is grateful to Dr. R. P. Marshall for the photomicrographs reproduced in this figure and to the late Dr. L. O. Overholts for the one given in fig. 2.

Peck reported the type of *Meliola balsamicola* as being associated with *Pezisa* (*Tapesia*) *balsamicola* n. sp. on "living or languishing leaves of balsam fir." A single apothecium of the latter is shown in FIG. 1, *A*. Three needles were also observed showing the perithecia of Peck's other species, the much discussed *Asterina nuda.* The latter fungus is so commonly distributed that it was not surprising to find some of it in needle collections of the *Meliola.* The type specimen of *P. balsamicola,* which was also examined, contains material of the *Meliola* and it was in this material rather than in the type of *M. balsamicola* that the writer found the olive-brown, bilocular ascospores. The writer examined perithecia on only a very few needles of the type specimen but undoubtedly mature colored spores are to be found in it.

ASTERINA NUDA Pk. 1885

On the type packet Peck wrote the name, *Asterina nuda,* which was reported both by himself (**11**, p. 102) and Martin (**7**, p. 134) in 1885. Later in 1909 when a list of species and varieties of fungi described by Peck (**12**, p. 65) appeared, the same name, *A. nuda,* was used with a single synonym, *Asterella nuda* Sacc. The type collection, which is not a large one, consists of needles that were dead at the time of collection. In it, among others, is an organism commonly present, which Peck undoubtedly intended as his *Asterina nuda* (FIG. 1, *B, D*). Material of *Meliola balsamicola* is not present. Perithecia of *A. nuda* on two needles were examined. As described by Theissen (**18**, pp. 72–73), Steiner (**17**), and Rohde (**15**), all of whom examined American material of the species, the fruiting bodies are distributed linearly along the stomatal openings, mostly on the lower (FIG. 1, *B*), but also on the upper needle surfaces where stomata likewise occur. In their dry condition the fully mature perithecia appear as if lacquered. They are tenacious, leathery, dull-shining, coarsely granular, becoming flattened cakelike and umbilicate, the elliptical ones having a deep, irregular suture (FIG. 1, *D*). The perithecia (FIG. 2) are formed superficially from well developed "stalks" arising from the stomata. The stalks are connected with what may be called "basal plates" of interwoven hyphae in the parenchyma tissue of the needle (**15**, FIG. 10; **17**, FIG. 12). The bilocular ascospores within the asci are hyaline, but occasional free, olive-brown ones are to be found. Paraphyses, which were not recorded by Peck, were not observed.

In fresh material of the species, an important unreported morphological development preceding ascospore discharge was observed. Before spore ejection, the sheath of the endoascus becomes elongated as a slender "clamlike" neck, at times becoming approximately as long as the ascus. As this inner sheath is extended, the walls of the ascus shrink in width so that the sheath appears as a tubular structure with a somewhat narrower necklike prolongation. These endoascus extensions that have been emptied of their spores persist as tubular sacs and are faintly but unmistakably discernible. The writer also observed them to be present in Peck's type.

In addition to the type and fresh material of *Asterina nuda*, the following specimens of it were studied; some had been incorrectly determined and all but one were collected in New York State:

(1) *Asterina nuda* Pk. Sandlake. Coll. Peck, June.
(2) *Asterella nuda* (Pk.) Sacc. N. Elba. Coll. Peck, June–Sept.
(3) *Asterina nuda.* Bathurst, N. B. Coll. Richards, July, 1892 (Herb. W. G. Farlow).
(4) *Dimerosporium balsamicola* (Pk.) Ell. & Ev. N. Elba. Coll. Peck, June, 1911 (det. Sacc.).
(5) *Dimerosporium balsamicola* (No. *1454*). Tupper Lake. Coll. House, Aug., 1913 (det. Sacc.).
(6) *Dimerosporium balsamicola* Newcomb. Coll. House, June, 1921.
(7) *Asterina nuda.* Newcomb. Coll. House, June, 1922.
(8) *Asterina nuda.* North Creek. Coll. House, June, 1923.
(9) *Dimerosporium balsamicolum.* Tahawas. Coll. House, June, 1923.
(10) *Asterina nuda.* Lake Sanford. Coll. House, Aug., 1924 (det. Dearness).

The 1911 and 1913 specimens of *Asterina nuda* mentioned, which were determined incorrectly by Saccardo (**16**, p. 115) as *Dimerosporium balsamicola,* have mostly hyaline or dilutely colored two-celled ascospores within the asci. Free olive-brown or sooty brown ascospores are also encountered. Only occasionally did the writer observe swollen, nonextended asci with brown spores. In one instance (specimen no. *1454*) an elongated discharging ascus was noted containing three colored bilocular spores at the base of the sac. The walls of this sac had shrunken in width to form a tubular structure, the upper part of which was elongated, and the extension of the endoascus contained one sooty brown spore. Although brown ascospores were readily evident to the writer and Dr. A. M. Waterman, who at the writer's request independently corroborated some of his observations, they were not observed by Saccardo (**6**, p. 46; **16**, p. 115).

Colored ascospores that become sooty brown upon full maturity are to be found likewise in the Sandlake, Newcomb, Tahawas, and Lake Sanford collections listed above. Dearness annotated the Lake Sanford specimen packet as follows: "I think this is Peck's *Asterina nuda* although I failed after trials on three different twigs to get asci and spores." The extended empty endoasci described previously are present moreover in the Sandlake, Newcomb, and Tahawas material.

TAXONOMICAL DISCUSSION

A consideration of the foregoing morphological data regarding *Meliola balsamicola* and *Asterina nuda* makes it difficult to understand how some mycologists could confuse the two species. In 1892 Ellis and Everhart (**2**, pp. 35, 36) had recognized the separate identities of Peck's two species when they published his *Meliola* as *Dimerosporium balsamicolum* despite Peck's (**10**, p. 52) opinion of 1881 that: "Our fungus does not fully meet the requirements of the genus *Meliola*, neither is it a good *Asterina* nor *Dimerosporium*. It needs further investigation." Twenty-eight years later Peck (**12**, pp. 65, 129) relisted his *Meliola* and *Asterina* species separately, but failed to take cognizance of the change Ellis and Everhart had made in the name of the former controversial fungus. Subsequently Saccardo (**16**, p. 115) caused considerable confusion when he united the two species under *D. balsamicola*.

Preliminary observations made by the writer upon which a further study of *Meliola balsamicola* may be based, indicate that it belongs to the Perisporiaceae (Phaeodidymae) and probably in the genus *Dimerium* Sacc. & Syd. This genus contains the interesting parasite, *Dimerium Juniperi*, described by Dearness (**1**, p. 244) as a new species with small, dark, crustaceous subicula strikingly seated in association with resinous glandular pits on the middle of the back of green leaf scales of *Juniperus occidentalis* Hook. (*California*).

The type specimen of the parasite, *Meliola balsamicola,* and material of it in the type collection of *Peziza* (*Tapesia*) *balsamicola,* are the only specimens known to the writer. Although parts of Peck's type of *P. balsamicola* possibly containing *M. balsamicola* have been deposited at the New York Botanical Garden, part of the *Meliola* type is not present there. One wonders whether *M. balsamicola* is a rare fungus in contrast with the much investigated *A. nuda,* which occurs commonly and abundantly over wide areas in North America and sparsely in Europe on a number of *Abies* spp.

Over a period of more than fifty years *Asterina* (*Adelopus*) *nuda* has been studied by a number of our leading mycologists. However, colored ascospores, which are so characteristic of the species when it is fully mature, were not observed by any of them. In this regard it should be remarked that Waldie wrote on March 31, 1927 to Professor J. S. Boyce, Yale University, New Haven, Conn., commenting on spore coloration in *A. nuda* as follows: "I wonder if . . . brown color might not develop at a very late stage. . . . It is worth watching for." Wilson and Waldie (**20**: 152–153) apparently did not succeed in finding dark spores. Petrak (**13**) also speculated on spore coloration but unfortunately appropriate material of *A. nuda* was not at hand to enable him to make this observation.

Because of a general interest in *Adelopus* (*Asterina*) *nudus* and the uncertainties concerning its name, the species has inherited an involved synonomy. Dearness aptly described the situation in an informative letter to the writer on September 14, 1941: "It makes me happy to think you are seriously attacking *Adelopus* on conifers. . . . I have perspired over the (?) synonomy of what I take to be *Adelopus* alias *Dimerosporium balsamicola*. . . . Have you referred the following names to their proper place?" Therewith he listed a long series of names and added a little sketch of an *Adelopus* perithecium with its hidden or secret (adelo, αδηλο) foot or stalk (pus, πους). The writer's interpretation of the relationship of the binomials involved is as follows:

ADELOPUS NUDUS (Peck) Hoehn. Sitzb. Akad. Wiss. Wien, math.-nat. Kl. **127** (1): 619. 1918.

Asterina nuda Pk. 38 Ann. Rpt. N. Y. St. Mus. Nat. Hist., p. 102. 1885.
Asterella nuda Sacc. Syll. Fung. **9**: 397. 1891.
Cryptopus nudus Theiss. Ann. Mycol. **12**: 72. 1914.
Adelopus balsamicola Theiss. Ann. Mycol. **15**: 482. 1917.
? *Phaeocryptopus nudus* Petr. Ann. Mycol. **36**: 14. 1938.

DIMEROSPORIUM BALSAMICOLA (Pk.) Ell. & Ev. North Am. Pyr., p. 728. 1892.

Meliola balsamicola Pk. 34 Ann. Rpt. N. Y. St. Mus. Nat. Hist., p. 52. 1881.
Asterina balsamicola Pk., in herb. (on label of type packet).
Zukalia ? balsamicola Sacc. Syll. Fung. **9**: 432. 1891.

The combination *A. nudus* (Pk.) Hoehn. is preferred for the species rather than *A. nudus* (Pk.) Theiss. published by von Hoehnel (**5**: 617–619), who gave "Theiss." rather than himself as author. In adopting the former combination, which is in accordance with International Rules, the writer has followed Petrak (**13**:

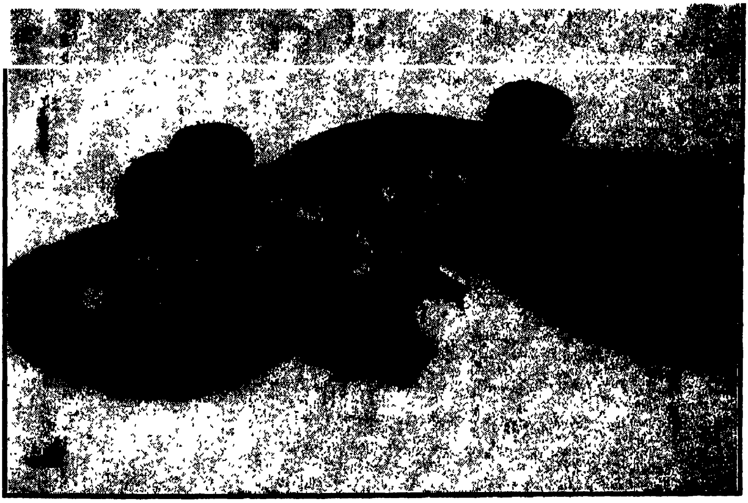

FIG. 2. Perithecia of *Adelopus nudus* on dead needle of *Abies balsamea.* × 95.

10, 15) rather than Rohde (15), who used the combination published by von Hoehnel.

As will be noted, the synonymity of *Adelopus* (1917) with *Phaeocryptopus* (1914) is questioned. In an extensive paper Petrak (13) gave reasons in favor of synonymity but unfortunately they are not based on an examination of the type, *Phaeocryptopus Abietis* Naoumoff (8, p. 424; 9, p. 20) collected on needles of *Abies sibirica* Ledeb. from the Ural Mts., Siberia. Moreover, Petrak did not study American material of *Adelopus nudus*. The perithecia of both genera appear to resemble each other closely and they are evidently formed in the same manner. Those of *Phaeocryptopus*, however, are reported as being paraphysate (8, pl. 32, fig. 2; 9, p. 20) whereas paraphyses are definitely lacking in *Adelopus*. Theissen (18), von Hoehnel (4: 265–266, 5), Wilson and Waldie (20), and Rohde (15) have all reported on the absence of these structures. Their observations confirm those made by the writer and Waterman, who has made a considerable number of examinations of *nudus* material. On the other hand Wilson and Waldie (20) when they recorded *nudus* in Scotland also reported *P. Abietis* on needles of herbarium specimens of *A. Faxoniana* Rehd. & Wils., collected in N. W. Yunnan, China. In the latter they described the occurrence of filiform, hyaline paraphyses, 70 × 2.5 μ; those reported by Naoumoff were similar in shape and size. The writer has been unable to study material of Naoumoff's *P. Abietis* for it is lacking in American herbaria.

The classification of *Adelopus* (= *Cryptopus*) Theiss. (18: 72–73) based on the species *Adelopus nudus* in the Capnodiaceae (Hyalodidymae) as indicated by Petrak (13: 12–13) is questionable. This study has shown that colored ascospores are produced by *nudus*. On the other hand, only hyaline spores are formed in the new species, *A. Gäumanni*, as has been amply demonstrated by the intensive studies of Steiner (17), Rohde (15), Petrak (13), and those of the writer as yet unpublished. Our concept of *Adelopus*, therefore, must be broadened to include species with colored as well as hyaline spores.

SUMMARY

For the first time since the days of Peck, his two type specimens, *Meliola balsamicola* 1881 and *Asterina nuda* 1885, both collected on *Abies balsamea* (L.) Mill., have been studied. Results show that these two organisms regarded as synonymous by Saccardo, who studied American specimens of *A. nuda,* are not only distinct species as Peck stated, but also belong to different genera.

Meliola balsamicola, a little known and rarely collected species on green balsam fir needles, does not belong either to *Meliola,* or to *Dimerosporium* where Ellis and Everhart placed it. It belongs to the Perisporiaceae (Phaeodidymae) and probably in the genus *Dimerium;* additional collections as well as an intensive study of it are needed.

Asterina nuda, a common fungus on dead fir needles, has been investigated extensively abroad for many years. The name preferred for the fungus, the involved synonomy of which is discussed, is *Adelopus nudus* (Pk.) Hoehn.

New morphological data for both species are given.

DIVISION OF FOREST PATHOLOGY,
BUREAU OF PLANT INDUSTRY,
SOILS AND AGRICULTURAL ENGINEERING
IN COÖPERATION WITH
THE OSBORN BOTANICAL LABORATORY,
YALE UNIVERSITY,
NEW HAVEN, CONNECTICUT

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NOTES AND BRIEF ARTICLES

MYCOLOGICAL SOCIETY OF AMERICA

REPORT OF THE 1946 FORAY

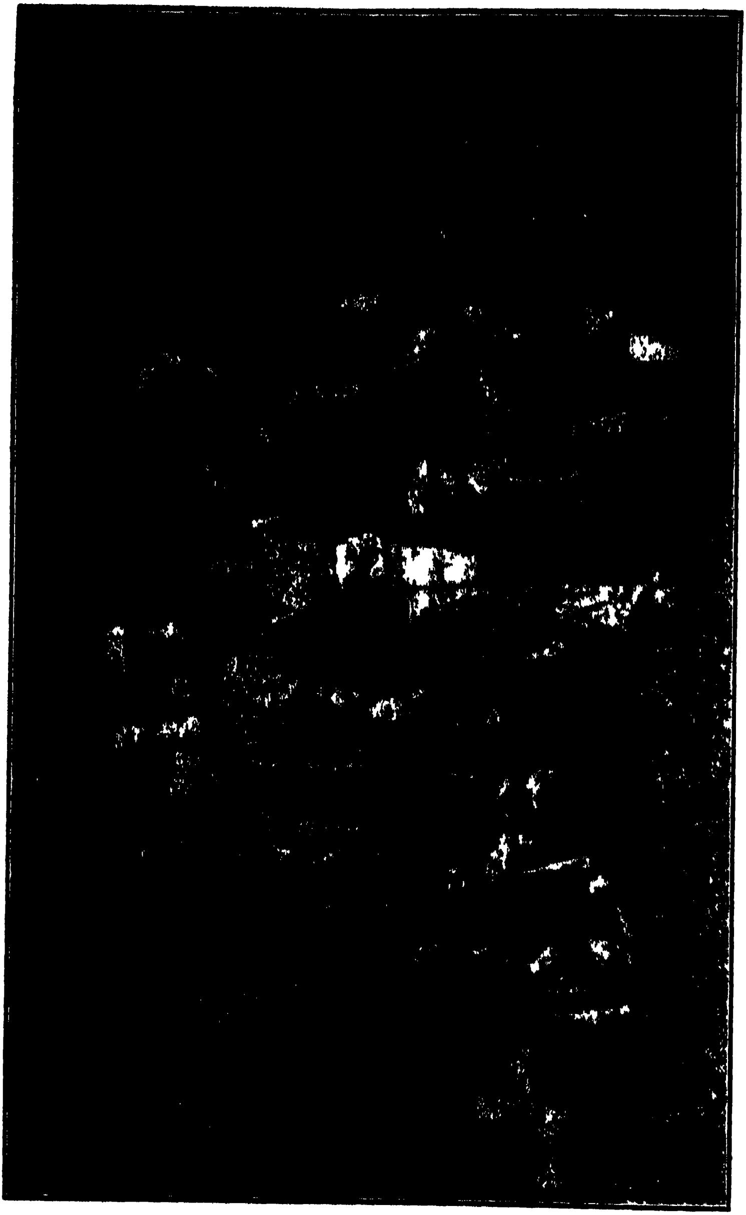
(WITH 1 FIGURE)

At the twelfth annual meeting of the Mycological Society of America at St. Louis in March 1946, it was directed that the mycological summer forays, long one of the popular activities of the Society, be resumed. The invitation, extended to the Society by Dr. C. R. Orton, Dean of the College of Agriculture and Director of the Agricultural Experiment Station of the University of West Virginia, on behalf of himself and his colleagues in the Department of Plant Pathology, to hold the first of the new series of forays in his State was accepted. The Southern Appalachian Botanical Club participated.

Headquarters were established in the laboratories of the Plant Pathology Department where facilities were available for arranging, drying and studying collected material. Dr. H. L. Barnett served very efficiently as local chairman and guide for the collecting parties. The group assembled at Morgantown on the afternoon of August 29 and left the following morning for Cheat Bridge and vicinity in Randolph County, collecting there in the afternoon and at two points along Route 250, north of Elkins, en route.

The night was spent at Elkins, where Dr. Ernst Bessey entertained with reminiscences of early collecting days in Colorado. Activities on the second day included a visit to Blackwater Falls State Park and collecting south of Davis and at a point on Route 219 just within the boundaries of Preston Co. The day was to have been concluded with a tour of the famous Cranesville Glades, but there appears to be reasonable doubt as to whether anyone but Dean Orton actually reached the Glades.

About thirty people, including the local group, were in attendance. Continued dry weather had limited very definitely the num-



The Mycological Society's foray West V

Photograph by H L Barnett

ber of fungi available, particularly of fleshy forms, but nevertheless an enjoyable as well as worthwhile time was had by all participating.

Sunday morning, September 1, was given over to study and care of collections. There was also available for inspection at this time a series of carefully prepared exhibits covering some of the work in mycology and plant pathology of staff members. The visitors were entertained later in the day by an informal gathering and picnic supper at Chestnut Ridge camp, a few miles out of Morgantown. Local collecting was the order of the day on Monday, followed in the evening by a most pleasant get-together at the home of Dean and Mrs. Orton.

The thanks of the Society have been extended to Dean Orton and his associates for the many and varied efforts put forth to make the foray a success.—JOHN A. STEVENSON.

BOOKS AND WORLD RECOVERY

The desperate and continued need for American publications to serve as tools of physical and intellectual reconstruction abroad has been made vividly apparent by appeals from scholars in many lands. The American Book Center for War Devastated Libraries has been urged to continue meeting this need at least through 1947. The Book Center is therefore making a renewed appeal for American books and periodicals—for *technical and scholarly books and periodicals in all fields* and particularly for *publications of the past ten years.* We shall especially welcome complete or incomplete files of MYCOLOGIA.

The generous support which has been given to the Book Center has made it possible to ship more than 700,000 volumes abroad in the past year. It is hoped to double this amount before the Book Center closes. The books and periodicals which your personal or institutional library can spare are urgently needed and will help in the reconstruction which must preface world understanding and peace.

Seated, L. to R.—H. M. Fitzpatrick, M. B. Walters, J. B. Routien, Mrs. Routien, E. A. Bessey, C. L. Shear, J. A. Stevenson, Mrs. Shear, Miss Walters, Miss Ryan, Miss Hayes. Standing, L. to R.—H. L. Barnett, W. W. Diehl, Mrs. Fitzpatrick, J. G. Leach, R. W. Davidson, C. T. Rogerson, J. G. Brown, Miss Cash, Mrs. Dayton, Mrs. Stevenson, W. L. Dayton, Mrs. Walters, Mr. Mozingo, L. K. Henry, Miss Dayton.

Ship your contributions to the American Book Center, c/o The Library of Congress, Washington 25, D. C., freight prepaid, or write to the Center for further information.—A. H. SMITH.

A NEW COMBINATION FOR BRUNCHORSTIA GIBBOSA

Recently there has come to the writer's attention a doctorate dissertation[1] dealing with *Crumenula* on pine. This monographic paper is of particular importance to forest pathologists in this country where the genus *Crumenula* with its imperfect stage, *Brunchorstia* Eriks., is little known. It includes a discussion,[1] pp. 66–68, of the new species, *Brunchorstia gibbosa* Wr., which Wollenweber,[2] pp. 498–499, published in 1931 after he had received material from the writer for identification. This material had been collected originally by Dr. J. S. Boyce, Yale University, New Haven, Conn., on cankers of Douglas-fir [*Pseudotsuga taxifolia* (Poir.) Britt.] near North Bend, King Co., Washington, in 1927 and had been sent for examination to the writer, who at the time was investigating Douglas-fir cankers in Great Britain. Boyce also sent some of this canker material to Dearness for his opinion. In 1928 Dearness described[3] the North Bend specimen (Herb. J. S. Boyce *1285, 1766;* collections for study, U. S. Div. Forest Pathology, *40,394;* Herb. Dearn. *5666*) as the new species, *Cryptosporium Boycei.*

A consideration of the genus *Cryptosporium* Sacc. would serve to indicate that the Boyce fungus does not belong there. The species should now be known as **Brunchorstia Boycei** (Dearn.) comb. nov. with *B. gibbosa* and *Cryptosporium Boycei* as synonyms. Ettlinger grew in culture what he regarded as a European isolate of *B. gibbosa* (= *Boycei*) (from *Abies alba* Mill.) and compared its characters with those of *B. pinea* (Karst.) Hoehn. (= *Crumenula abietina* Lgbg.[1]) and *B. laricina* Ettlinger (= *Crumenula laricina* Ettlinger[1]). He stated that the characters of this fungus were so different from those of the two other species that he doubted a relationship between it and *Crumenula*. It would be interesting to compare the cultural characters of the isolate from *A. alba* with those of the species isolated from Douglas-fir in the United States.—GLENN GARDNER HAHN.

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[2] Wollenweber, H. W. *Fusarium*-Monographie. Fungi parasitici et saprophytici. Zeitschr. f. Parasitenkde. 3: 269–512. 1931.

[3] Dearness, J. New and noteworthy fungi—V. Mycologia 20: 235–246. 1928.

NOTICE

It has been called to our attention that beginning with Volume 10, 1947, the TAXONOMIC INDEX, a publication of the American Society of Plant Taxonomists, will include a section on the systematics of the fungi. All those interested in receiving this service may communicate with the Editor, W. H. Camp, New York Botanical Garden, New York 58, N. Y.—A. H. SMITH.

NOTICE

For a number of years past, the early volumes of MYCOLOGIA (Vols. 1–24 plus index) have been selling under our special offer of $50.00, much below the original cost of printing. Because of dwindling stock it will be necessary to withdraw this offer after July 1, 1947, and offer these at the regular publication price indicated on the covers.—FRED J. SEAVER.

MYCOLOGIA

OFFICIAL ORGAN OF THE MYCOLOGICAL SOCIETY OF AMERICA

VOL. XXXIX SEPTEMBER–OCTOBER, 1947 NO. 5

THE GENUS CANTHARELLUS IN THE WESTERN UNITED STATES *

ALEXANDER H. SMITH AND ELIZABETH E. MORSE

(WITH 13 FIGURES)

Since species of *Cantharellus* are conspicuous elements of the agaric flora of our western states, and because several are important edible species, it appeared desirable to bring our information on them up to date. We ourselves did not realize the full extent of the need for a comprehensive treatment of this genus for the region until several seasons of concentration had served to focus our attention on a number of problems. In the past the difficulties of working with species of *Cantharellus* in this area were twofold. Reports of the species were scattered in the literature and contained very little essential information. No work was available which focused attention on the problems peculiar to the region. It now appears that a number of conspicuous elements in the flora were undescribed.

In keeping with the present day trend in the classification of the gill fungi, we recognize the family Cantharellaceae as a family distinct from the true gill fungi, and one most closely related to the Clavariaceae. The characters of the basidia indicate this relationship. In both groups the basidia bear from two to eight spores and the spindles of the dividing nuclei are arranged more or less parallel to the longitudinal axis of the basidium instead of at right angles to it. There is also considerable intergradation in the type

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* Papers from the Department of Botany and the University Herbarium. The excess illustrations were paid for by the University of Michigan Herbarium.

[MYCOLOGIA for July–August (39: 379–495) was issued August 11, 1947]

of fruiting body produced, the configuration of the hymenium, and the type of spores. The following key to the genera of the family is given as an aid to those whose interest extends beyond the scope of this paper. In this key we have not tried to delimit the Clavariaceae sharply from the Cantharellaceae. Most of the intergrading species probably are best placed in *Craterellus*.

KEY TO THE GENERA OF THE CANTHARELLACEAE

A. Fruiting body typically fleshy and centrally stipitate or stipe eccentric but well developed (in some the stipe and pileus not clearly distinct, the fruiting body then being in the form of a trumpet or funnel).
  1. Hymenium smooth or nearly so........................*Craterellus*
  1. Hymenium in the form of distinct radiating ridges or folds or as obtuse forked lamellae..............................*Cantharellus*

A. Fruiting body very thin and delicate; stipe if present very small and rudimentary.
  1. Spores hyaline..*Leptotus*
  1. Spores tawny to incarnate...............................*Arrhenia*

CANTHARELLUS Fries, 1821

Fruiting body fleshy to moderately tough, sometimes woody when dried, pileate to tubular or trumpet-shaped, pileus and stipe not always clearly distinct; hymenium borne on the under side of the pileus and upper portion of the stipe, usually in the form of narrow gill-like folds which branch dichotomously or anastomose and have obtuse edges, usually strongly intervenose and in some species occasionally somewhat poroid from the pronounced cross-veins, often with a waxy luster; basidia typically elongated and with flexuous pedicels, two to eight spored, reaction in KOH typically negative in all but the first two sections. (In *C. Underwoodii* it is olive; in *C. pseudoclavatus* and *C. clavatus* it is dull brown or orange-brown respectively.) Spores white to yellowish to pale alutaceous in deposits, smooth or with the outer wall slightly wrinkled or pitted, nonamyloid (yellow to rusty brown in iodine solution); hyphae of the gill and pileus trama scarcely distinguishable in shape or form from each other, typically hyaline in KOH, but in one group with a slight coloration; clamp connections either present or absent depending on the species; cystidia typically absent.

The present study brought out some interesting groupings of species within the genus, and as a result of it the following sections are recognized:

SECTION I: **Polyozellus.** The single species in this section was made the type of the genus *Polyozellus* by Murrill. However, we define the section as characterized by the small, roughened, hyaline spores and the color change of the flesh in KOH rather than by the characters used by Murrill in erecting it as a genus.

SECTION II: **Gomphus.** This section contains three species, *C. clavatus, C. pseudoclavatus* and *C. brevipes.* This group has been recognized as a genus, *Neurophyllum* Patouillard and *Gomphus* S. F. Gray, both based on *C. clavatus.* In our estimation this is not an acceptable arrangement because it is difficult to find any characters other than general aspect which will distinguish between *Gomphus* and Eu-Cantharellus. We define the section Gomphus as containing species similar in appearance to *C. clavatus.* It is interesting to note in this group that clamp connections are abundant on the type species, *C. clavatus,* which is circumpolar in distribution, but absent on the other two which appear to be relatively local segregates of it. In our estimation such occurrences as this are sufficient reason for not placing great emphasis on the presence or absence of clamp connections in erecting new genera. For here in *Cantharellus* we have groups in which *so far* clamps have not been found (Section Excavatus), one section in which the central species has them but the segregates do not (Section Gomphus), and two sections where, in so far as we know them, clamps are regularly present.

SECTION III: **Eu-Cantharellus.** The type of this section as well as for the genus is *C. cibarius.* In our region the section is represented by only two species, the type and *C. subalbidus.* The section may be defined as containing fleshy species with essentially smooth pilei, in other words fungi resembling *C. cibarius* in general aspect. In the Western United States *C. cibarius* is extremely variable, but we have not attempted to classify variants below the species level because of the lack of any constant characters. Clamp connections are found on both species. The origin of this section appears to us to be in Europe for it is there that one finds the largest number of species described which are obviously closely related to *C. cibarius,* and the latter, itself, is very common. There have been a number of varieties of *C. cibarius* described from Europe which, if the descriptions are correct, appear to be autonomous species.

SECTION IV: **Excavatus.** The characters of this section are the innately fibrillose scaly to squamose pileus which in most species becomes hollowed out to produce a deep central depression or becomes hollow almost to the base of the stipe. The type of this section, logically, is *C. floccosus* since it appears to be the one from which the others have been differentiated. The section contains *C. Kauffmanii, C. floccosus, C. Bonarii* and *C. Wilkinsae.* In the order named these species show a progressive change from the very fleshy-brittle type as represented by *C. Kauffmanii* to the semi-woody condition found in *C. Wilkinsae.* In addition to the character previously mentioned the section is characterized by the spores, which are rusty brown in iodine, and the lack of clamp connections on the hyphae of the fruiting bodies. Although *C. floccosus* was originally described from the eastern seaboard, it appears clear to us that the center of distribution for the section is the region under consideration here. As evidence for this statement we cite the number of species known from the area (it is larger than that known for any other region), the abundance of most of the species and the great variation observed in the type, *C. floccosus.*

SECTION V: **Tubaeformis.** We regard this as a group in which the species are not yet properly classified and in which the nomenclature remains to be worked out. We believe there is little to be gained here by nomenclatorial studies until such time as workable species concepts become established. In our opinion this section promises to be one of the largest in the genus and our information so far indicates northeastern North America and the Great Lakes Region as being the critical area. It may be defined as containing species similar in general aspect to *C. tubaeformis.*

EXCLUDED SPECIES: As limited here *C. umbonatus* with amyloid spores, *C. olidus* and *C. aurantiacus* are excluded from *Cantharellus. C. umbonatus* is now the type of the genus *Cantharellula* Singer and the others are placed in *Clitocybe* by most investigators since they are regarded as true gill fungi. All of these species occur in our region and since they are likely to be sought for in *Cantharellus,* they have been included in our key to species.

A number of apparently very rare and obviously poorly known species have been reported from the area. These have been omitted from this work. For instance *C. albidus* Fr. has been reported, but the only specimens examined turned out to be *Omphalina umbellifera.*

We have also refrained from citing long lists of collections. The specimens upon which this paper is based will be found in the Herbarium of the University of Michigan, Herbarium of the University of California, and in the Morse Collection, Bureau of Plant Industry, Beltsville, Maryland. The color names in parentheses are taken from *Color Standards and Color Nomenclature,* by R. Ridgway, 1912.

It is a pleasure to acknowledge the assistance of our colleagues who have aided this investigation by collecting material or making available material deposited in the herbaria of their respective institutions. We are indebted to Dr. H. D. House, New York State Museum, Albany, N. Y., for the opportunity of examining certain of Peck's types. Dr. Lee Bonar of the University of California made available to us the critical collections of *Cantharellus* at that institution. To the others who likewise aided us in our project we extend our sincere thanks.

KEY TO THE WESTERN SPECIES OF CANTHARELLUS

1. Spores amyloid; pileus typically grayish to violet-gray; gills close, white and staining yellowish to reddish when bruised.
Cantharellula umbonata (Fr.) Singer
1. Spores not amyloid..2
2. Lamellae close to crowded..3
2. Lamellae distant to subdistant or merely in the form of ridges (if close not bright orange and flesh not with an odor of cinnamon candy)......4
3. Gills bright orange; spores 5–7 × 3–4 μ; odor not fragrant.
Clitocybe aurantiaca (Fr.) Studer
3. Gills pale buff; spores 3–4.5 × 2.5–3 μ; odor typically reminding one of cinnamon candy........................*Clitocybe olida* (Quél.) Kon.
4. Flesh of pileus dark blackish green to olivaceous in dilute KOH.
1. *Cantharellus multiplex*
4. Flesh of pileus not as above when treated with KOH.................5
5. Surface of pileus not regularly breaking up into coarse recurved fibrillose scales...6
5. Surface of pileus soon broken up into coarse scales or cap splitting into a number of segments...11
6. Hymenium typically tinged vinaceous, purplish or smoky violaceous; carpophores typically large (3–10 cm.)............................7

6. Hymenium white to yellow or orange, if colors clouded with gray the fruiting bodies small (1–3 cm. or up to 5 cm.)......................8
7. Spores smooth; hymenium sordid bister in KOH....2. *C. pseudoclavatus*
7. Spores roughened; hymenium orange to orange-brown revived in KOH. 3. *C. clavatus*
8. Pileus typically large, 3–10 cm...................................10
8. Pileus typically small and perforated, grayish to sordid yellowish brown..9
9. Spores white to whitish in deposits..................10. *C. tubaeformis*
9. Spores ochraceous to ochraceous salmon in deposits. 11. *C. infundibuliformis*
10. Pileus gills and stipe pallid, spore deposit whitish.......4. *C. subalbidus*
10. Pileus gills and stipe yellow to orange; spore deposit "light cinnamon buff" (yellow)......................................5. *C. cibarius*
11. Pileus very brittle, never with orange or reddish hues in the scales, hymenium becoming merulioid......................6. *C. Kauffmanii*
11. Not with above combination of characters..........................12
12. Fruiting bodies often cespitose or several arising from a common stipe, numerous small aborted carpophores often present in clusters. 8. *C. Bonarii*
12. Fruiting bodies typically gregarious to scattered..................13
13. Spores smooth; cap splitting into distinct segments; texture, semi-woody...9. *C. Wilkinsae*
13. Spores with slightly wrinkled exospore; cap not splitting into distinct segments (though sometimes scales may be very coarse); scales orange to bright yellowish orange............................7. *C. floccosus*

1. CANTHARELLUS MULTIPLEX Underwood, Bull. Torrey Club 26: 254. 1899.

Polyozellus multiplex Murrill, North American Flora 9: 171. 1910.

Craterellus multiplex Shope, Mycologia 30: 373. 1938.

ILLUSTRATIONS: Bull. Torrey Club 26, p. 254; Mycologia 29, p. 287, fig. 1; *Ibid.* 30, p. 373, fig. 1.
FIG. 1.

Fructifications 6–15 cm. high and up to 1 meter in diam., consisting of a mass of small to moderately large fan-shaped to spathulate pilei 2–5 × 3–10 × 0.1–0.3 cm., in robust carpophores the pilei at times somewhat funnel-shaped, surface indistinctly concentrically zoned with alternate zones of tomentum, or merely unpolished and somewhat roughened and then scarcely zonate, color glaucous violaceous but soon violaceous black or in age somewhat lead-colored, the margin pale glaucous violet to whitish and incurved when young, at times the margin undulating or lobed and usually pubescent at first; flesh rather soft and watery, brittle, dark violet-black, azonate, odor faintly pungent, taste mild, dark blackish green to olivaceous when treated with KOH; hymenium glaucous violaceous at first ("deep violet plumbeous"), in oldest portion tinged "cinnamon buff," in the form of radiating folds or ridges, the ridges frequently forking or anastomosing or at times giving rise to an almost poroid surface, merely tuberculate to slightly wrinkled where decurrent on the stipe, nearly smooth near cap margin; stipe 3–5 cm. long, 10–20 mm. thick, variously grown together near base or apex or fused in midportion, often irregularly compound, solid, dark violaceous black, fibrous, brittle, slightly roughened and upper part covered by the decurrent hymenium.

Spores white in deposits, broadly elliptic to spheric in outline, tuberculate to angular-tuberculate, 4–6 × 4–6 μ, hyaline to faintly yellowish in iodine; basidia 32–38 × 5–6 μ, four-spored, yellowish in iodine, faintly olivaceous in KOH (very likely from pigment diffusing from the flesh); cystidia imbedded and in the form of narrow somewhat contorted filaments 28–40 × 3–4 μ (readily demonstrated in sections crushed slightly and stained with phloxine); flesh of interwoven non-gelatinous hyphae with a dark bluish black incrusting pigment on the walls which dissolves into a green solution in KOH; clamp connections present on the basidia.

HABIT, HABITAT AND DISTRIBUTION: It occurs in great clusters or compound clusters on the humus under conifers in the fall or late summer. Material from Union Pass, Pitt Island, British Columbia (McCabe, Sept. 27, 1938), Mt. Rainier National Park, Carbon River Area (Leverett & Richards, Sept. 1930), and Mt. Hood, Oregon (*S–19275* & *24297*) has been studied.

DISCUSSION: It is known from scattered localities across the continent. The collections so far reported for North America, and verified by an examination of material, clearly indicate that the species is northern or alpine in distribution and rare. The white, angular-tuberculate spores and the dark bluish colors in conjunction with the KOH reaction of both fresh and dried material clearly distinguish this fungus from any other known member of the Cantharellaceae. To us the relationships appear to be with *C. clavatus* though it varies more toward *Craterellus*. It seems best, however, to classify it on the basis of the configuration of the hymenium which is cantharelloid in mature fruiting bodies. The spores are unusual for the genus but in our estimation do not warrant excluding the species.

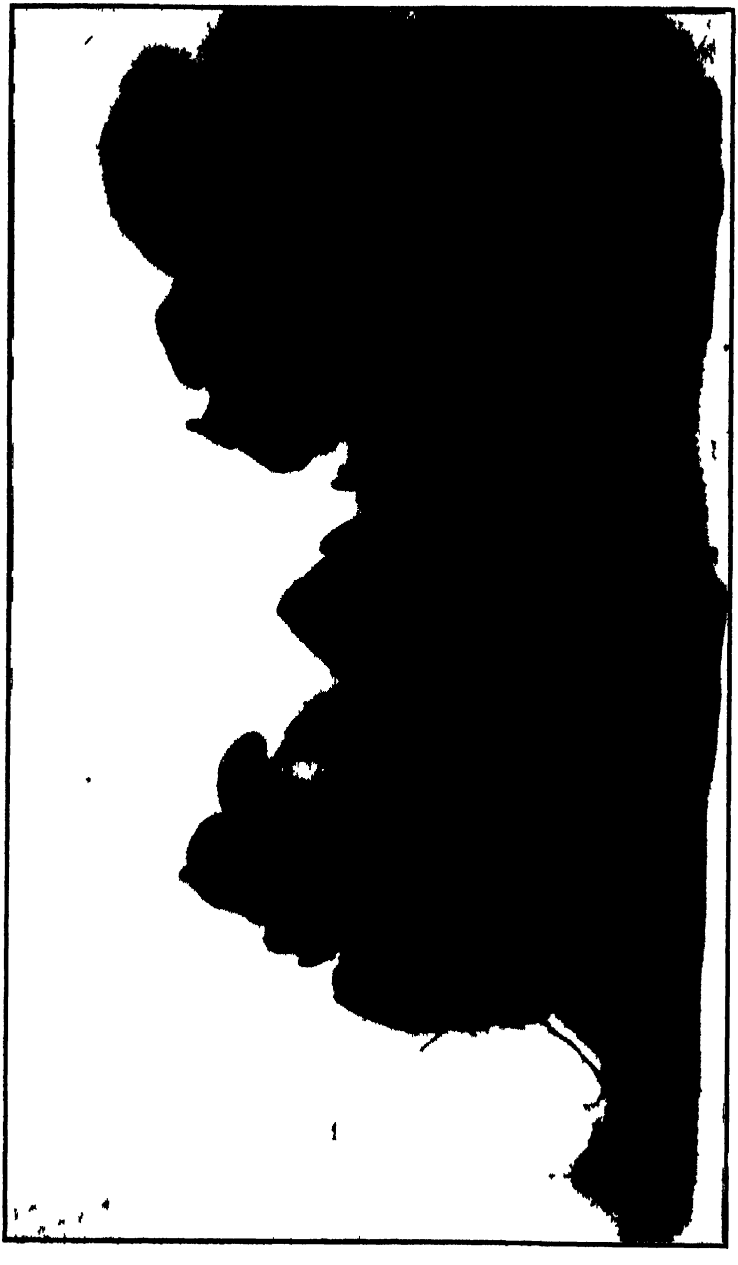

FIG 1 *Cantharellus multiplex* ×1

2. **Cantharellus pseudoclavatus** Smith sp. nov.

Pileus 3–8 (10) cm. latus, planus demum irregulare infundibuliformis, ad marginem undulatus, siccus, subfibrillosus, avellaneus vel sordide alutaceus, ad marginem subpurpureus; lamellae venosae, angustae, decurrentes, subpurpureae; stipes 2–4 cm. longus, 1–2 cm. crassus, solidus, subpurpureus, intus pallidus; sporae 9–12 × 5–6.5 μ, leves, subochraceae.

Pileus 3–8 (10) cm. broad, flat on top and not truly distinct from stipe when young, the margin soon spreading and becoming uplifted and often developing on one side only, pileus finally flabelliform to funnel-shaped, the margin usually very wavy and lobed in age, surface dry and unpolished or in age appressed fibrillose with the fibrils arranged in fascicles at times, color near "vinaceous buff," "cinnamon buff" or "avellaneous" when young, and often with a tinge of purplish pervading along the margin, finally sordid alutaceous but becoming drab in drying; flesh thick in the disc but thin in the extended margin, white to whitish, odor not distinctive, taste not recorded; hymenium variable in form and color, more or less gill-like with the radiating folds moderately close to distinct, narrow and connected by numerous cross-veins to such an extent that the appearance in old caps may be almost poroid, decurrent down almost to the base of the stipe, color when young purplish-vinaceous (colors not matched), in age dusted with the spores and with an ochraceous sheen; stipe 2–4 cm. long, 1–2 cm. thick, solid, pallid within, enlarged upward, surface more or less colored like the cap except for the white mycelioid base, unpolished to tomentose.

Spores yellow in deposits, 9–12 × 5–6.5 μ, subellipsoid, smooth, nonamyloid (pale yellow in iodine), thin-walled and nearly hyaline in KOH, content often appearing amorphous and wrinkled when first revived in KOH; basidia four- to eight-spored, 50–80 × 9–11 (12) μ, often flexuous, when revived in KOH the hymenium appearing sordid brown (pale bister), individual basidia nearly hyaline but with highly refractive amorphous-appearing content; cystidia none; gill trama interwoven, paler than basidia in KOH but thick sections bister like the hymenium to the naked eye, no clamp connections present even at base of basidia, hyphae 5–12 μ in diam. and thin-walled; pileus trama similar to gill trama, surface layer merely more compactly interwoven.

HABIT, HABITAT AND DISTRIBUTION: In this region it is known from one fruiting body found in a mixed woods near the Siskiyou Fork of the Smith River, northern California. In Michigan it has been found in both Washtenaw and Oakland counties in oak-hickory forests. It occurs in clusters much like *C. clavatus*. The

Michigan collections were made on Aug. 8 (*S-6877*) and Aug. 9 (*S-6916*. **Type**), 1937. The California material was found late in November, 1937. It was mistaken for *C. clavatus* in the field and not critically studied. The description has been drawn from the Michigan collections.

DISCUSSION: This species is so like *C. clavatus* in appearance that the senior author was completely deceived by it and discovered its distinctive features only after a routine check in the course of preparing material for accessioning in the herbarium. Microscopically the smooth, broadly ellipsoid spores, lack of clamp connections and reaction of the hymenium and flesh of the pileus and gills in KOH sharply distinguish it. Comments on its abundance and distribution are hardly appropriate at present.

Since *Cantharellus brevipes* also has the aspect of *C. clavatus* it had to be considered in connection with *C. pseudoclavatus*. Through the courtesy of Dr. H. D. House, the type has been examined and the following observations made: The spores are nearly hyaline in KOH. The tinge of color visible was in groups of spores adhering along the hymenium. They measure (12.5) 13–16 × 5.5–7 µ, and are nearly oblong in face view and in side view have a distinct suprahilar depression. The exospore is wrinkled as in *C. clavatus*. The spores, in fact, are similar to those of the European species in shape and markings but differ in length and in their slightly more dilute coloration. The basidia measure 40–50 × 7–8 µ and both two-spored and four-spored individuals were seen. However, the sterigmata are fine and difficult to observe. The color reaction in KOH of the basidia and subhymenium is merely sordid yellowish to brownish and not very distinctive. The colored zone is not sharply delimited as in *C. clavatus*, and to this extent as well as in the darker reaction of the basidia of the latter, the KOH reaction is an aid to their recognition. Cystidia or at least what appear to be sterile filaments are present in the hymenium but in the type it was not possible to be certain that these were not immature basidia. This point needs further clarification. The hyphae of the flesh are very intricately interwoven and 2–5 µ in diam. No clamp connections were found. In *C. clavatus* the hyphae are 5–10 µ in diam. and clamp connections are abundant.

Since *C. brevipes* has been considered to be the same as *C. floccosus* by Murrill and *C. clavatus* by Harper, a critical comparison with them is necessary. Since Peck described the cap of *C. brevipes* as glabrous and alutaceous, and the gills as pale umber tinged with lilac, and since the type seems to agree in the main with the description on these points, there is no reason whatever for considering *C. floccosus* further. Peck's suggestion of such a relationship was obviously based on the stature of the fruiting body and the configuration of the hymenium. *C. brevipes* can be distinguished at once from *C. pseudoclavatus* by its rough spores which measure (12.5) 13–16 × 5–6 μ. From *C. clavatus* it is distinguished by the narrow hyphae of the fruiting body and their lack of clamp connections. The spore size may also be significant but there is likely to be considerable variation in this character. There is the possibility that other differences will also be found, such as the color reaction in KOH when it can be definitely established on the basis of better material, and certain macroscopic characters, but the latter need to be restudied from fresh material.

C. mexicanus Fr. is described as having a grayish fuscous pileus, 3–4 cm. broad, and gills somewhat the color of *C. clavatus* but is said to differ in its well-formed gills, a character which relates it to *C. cibarius*. Two varieties of *C. cibarius*, var. *neglectus* Souché and var. *janthinoxanthus* Maire, have been described with grayish-violet or grayish lilac hymenium. The latter may possibly be the same as *C. pseudoclavatus* since its spores are 11–12 × 7–8 μ and smooth, but this is a question which cannot be answered at present. Maire placed his fungus in *C. cibarius* whereas I mistook the American species for *C. clavatus*—a fact which indicates that the plants must have quite a different aspect when fresh.

3. CANTHARELLUS CLAVATUS Fries, Syst. Myc. 1: 322. 1821.
Merulius clavatus Secretan, Mycogr. Suisse 11: 47. 1833.
Craterellus clavatus Fries, Epicr. Syst. Myc. p. 533. 1838.
Neurophyllum clavatum Patouillard, Tab. An. Fung. fasc. 5, p. 93, no. 434. 1886.
Craterellus carneus Saccardo, Fl. Ital. Crypt. fasc. 15, p. 1135. 1916.

Gomphus clavatus S. F. Gray, Nat. Arr. Brit. Pl. 1: 638. 1821.

Gomphus truncatus Persoon, Myc. Eur. 2: 9. 1825.

ILLUSTRATIONS: Kauffman, Ag. Mich. vol. 2, pl. II, upper figs.; Kauffman, Pap. Mich. Acad. Sci. 5, pl. V (as *Cantharellus multiplex*); Harper, E. T., Mycologia 6, pls. 93 & 94 (excellent).

FIG. 2.

Pileus (3) 5–10 (15) cm. broad, at first scarcely differentiated from the stipe (the fruiting bodies resembling truncate clubs), soon the margin spreading and frequently developing almost entirely on one side, frequently becoming broadly funnel-shaped from the uplifted margin or flabelliform, the margin usually extensively lobed or sinuate in age, the surface dry and glabrous, unpolished to velvety, in age at times minutely scaly, color at first dull vinaceous to purplish but soon fading to sordid brown ("dark purple drab" when young), soon fading through "light russet vinaceous" or "russet vinaceous" to "avellaneous" and finally "clay color" to "tawny olive"; flesh thick in the disc but thin (5 mm. ±) in the extended margin, whitish to pale buff ("cinnamon buff"), odor and taste mild; lamellae or hymenium variable in color but usually tinged purple or vinaceous ("purplish lilac" to "purplish vinaceous" and fading to near "avellaneous" or "light russet vinaceous"), formed of numerous low, crowded, frequently forked or anastomosing ridges and with numerous thick veins connecting the ridges, at times almost poroid in appearance, decurrent almost to the base of the stipe; stipe frequently compound, 4–10 cm. long, 0.8–3 cm. thick below and expanding into the pileus, sometimes many fused at the base into a large fleshy mass, solid, becoming hollow, whitish below from a thin mycelioid covering, purplish drab above.

Spores narrowly ellipsoid, 10–12 (13) × 5–6 μ, pale alutaceous in deposits, outer wall somewhat roughened, yellowish in iodine; basidia 65–80 (90) × 7–9 μ, four-spored, hymenium dull orange to orange-brown when revived in KOH; cystidia none seen; gill trama poorly developed, at first the portion near the subhymenium yellowish in KOH but soon fading and hyaline throughout; pileus trama with a cuticle of upright cells 40–80 × 2.5–6 μ, brownish in mass when revived in KOH (apparently from the slightly colored walls), nearly hyaline when isolated, forming a very compact turf, hyphae beneath hyaline and compactly interwoven, clamp connections abundant, flesh proper hyaline in KOH.

HABIT, HABITAT AND DISTRIBUTION: Occasionally gregarious but usually cespitose or in compound clusters which may even

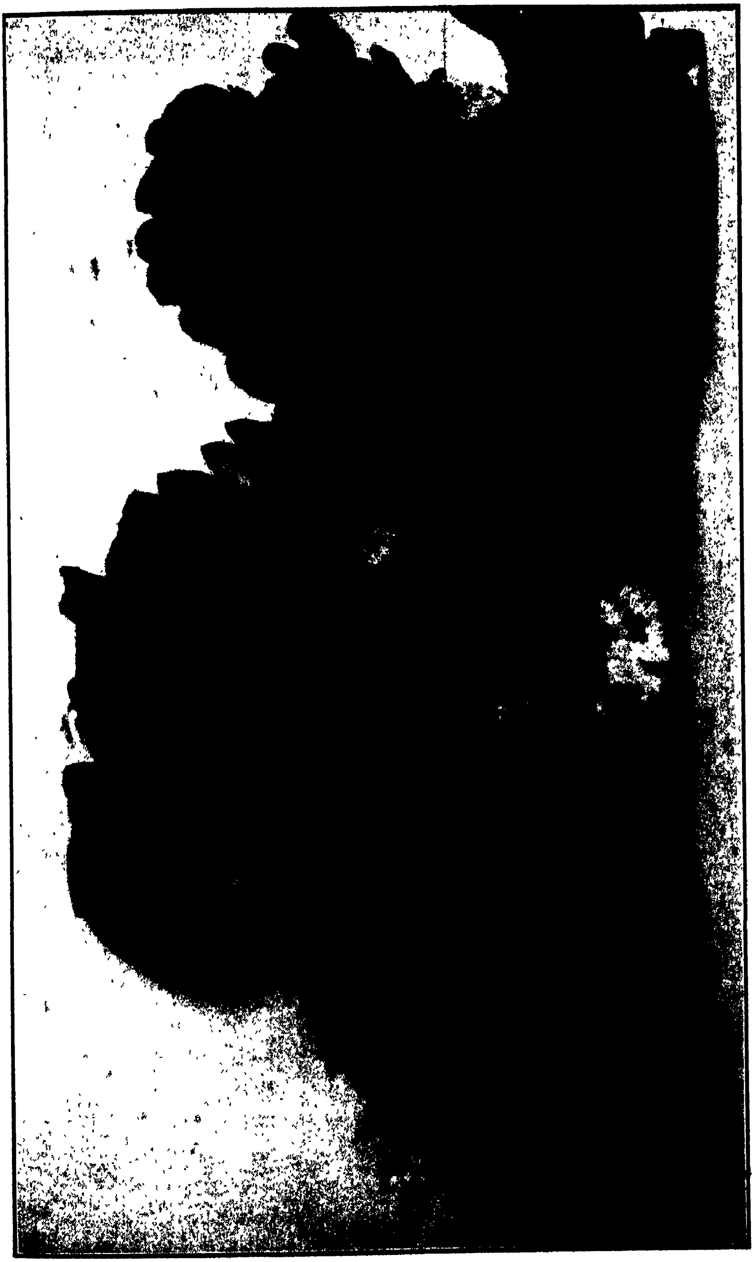

FIG. 2. *C. clavatus.* × 1.

occur in arcs or "fairy rings." It is typically on humus though often near very decayed logs, and is most abundant under conifers. It is a common species in northern California, Oregon and Washington in the fall, and occurs at all elevations up to near timber line. During the dry season of 1946 it was very abundant in the vicinity of Wemme, Oregon. We would expect it to be common in British Columbia also.

DISCUSSION: This is a very easily recognized species which one should not confuse with any others save *C. brevipes* and *C. pseudoclavatus.* The purplish to vinaceous tinge in the hymenium is characteristic of all three. The reaction of thin sections of the hymenium in KOH will at once distinguish this species from the other two. In *C. clavatus* the hymenium appears orange to orange-brown and the flesh proper is hyaline. In *C. brevipes* the KOH reaction does not appear to be distinctive and in *C. pseudoclavatus* the hymenium and the flesh become very sordid brown (bister). For further comments see discussion of *C. pseudoclavatus.*

4. **Cantharellus subalbidus** sp. nov. (FIG. 3)

Pileus 5–10 (14) cm. latus, subplanus, ad marginem demum irregulare lobatus, subtomentosus, siccus, albidus vel subalbidus; lamellae angustae, decurrentes, venosae, pallidae, demum luteo-maculatae; stipes 2–4 (5) cm. longus, 1–3 cm. crassus, sursum expansus, albidus demum luteo-maculatus; sporae 7–9 × 5–5.5 μ, leves, albidae.

Pileus 5–10 (14) cm. broad, at first plane or with a decurved margin, soon the margin elevated to somewhat recurved and becoming very irregularly lobed or wavy, in age broadly depressed to subinfundibuliform and quite irregular in shape, surface felty-fibrillose to subtomentose, smooth or in age areolate-scaly, typically dry and unpolished, often very uneven, white to whitish over all, becoming pallid buff when water-soaked and sordid yellow where handled; flesh thick, firm, fibrous, white with a tendency to stain yellow where bruised, odor and taste not distinctive; lamellae close and narrow, long-decurrent, variously forked or anastomosing and strongly veined, white to grayish white but becoming cream-colored and staining yellow to orange when bruised, edges obtuse and even; stipe 2–4 (5) cm. long, 1–3 cm. at base, flaring upward and indistinct from pileus (gills decurrent almost to base), solid, white and fibrous within, surface white and unpolished but staining yellow to orange when bruised, finally discoloring to sordid brown.

Spores white in deposits, 7–9 × 5–5.5 μ, ellipsoid to broadly ellipsoid, smooth, yellow in iodine; basidia 62–80 × 8.5–10 μ, narrowly clavate, hyaline in KOH but filled with many small oil globules, four to six-spored; pleurocystidia and cheilocystidia none seen; gill trama of loosely interwoven hyaline hyphae, the cells hyaline in KOH and usually filled with many oil drops, thin-walled, 5–8 μ in diam., regularly with clamp connections at cross walls. flexuous and often widened near cross walls; pileus trama homogeneous, the surface of more compactly interwoven cells than the tramal body but of the same type and similar to or slightly broader and more irregular than those of the gill trama.

HABIT, HABITAT AND DISTRIBUTION: Single to gregarious under conifers, particularly Douglas fir, Washington, Oregon and California. It fruits during the fall and winter rainy season and is often abundant.

DISCUSSION: For years this fungus has passed as a white form of *C. cibarius* in this region, but a critical study of it in the Mt. Hood area in 1944 brought out certain facts which indicate that the plant deserves to be ranked as an autonomous species. These observations were verified during the season of 1946. During the latter season Miss McKenny of Olympia, Washington, also brought the species to our attention and commented that it was abundant in her collecting area. We regard the difference in the color of the spore deposit between *C. subalbidus* and *C. cibarius* as fundamental. It is white in the former and "light pinkish cinnamon" in the latter. Fresh prints taken simultaneously were compared under identical light conditions (see collections *S–20030* & *S–20031,* Univ. of Mich. Herb.). The decidedly paler color of the fruiting body is a second constant difference which has always proven to be very reliable in the field unless one chanced upon very old faded *C. cibarius* in exposed places. The pronounced fragrant odor of *C. cibarius* is not present in *C. subalbidus* as far as our specimens to date are concerned.

C. albidus Fr. as described by some European authors appears to have essentially the same color and color changes as *C. subalbidus,* but is a much slenderer plant and according to Ricken has small spores 4–5 × 3 μ. Rea gives the spore size as 6–7 × 4–5 μ.

Inasmuch as accurate data on the color of the spore deposit is lacking on the European species no comparison can be made on that character. Ricken speaks of a white form of *C. cibarius,* but gives no data on the color of the spore deposit. He clearly distinguished between it and *C. albidus.* It is possible that *C. subalbidus* occurs in Europe, but this needs to be verified by a critical study of fresh material.

5. Cantharellus cibarius Fries, Syst. Myc. 1: 318. 1821 (fig. 4).

Chanterel Chantarellus Murrill, North Amer. Flora 9: 169. 1910.

Pileus 4–10 (15) cm. broad, nearly flat and with an inrolled margin when young, margin spreading or becoming uplifted in age and then cap broadly depressed to broadly funnel-shaped, usually wavy or lobed along the margin, surface dry and at first covered by a thin coating of pallid, fine, matted fibrils giving it a canescent appearance, appearing moist in age at times, margin finely pubescent, color pale yellowish young ("cinnamon buff") becoming bright yellow to orange ("antimony yellow" to "deep chrome") in age, finally fading to sordid buff; flesh rather thick and pliant, 1 cm. ± thick near the stipe, whitish or pale yellowish near cap surface, unchanging when bruised, odor fragrant or lacking, or when caps are dried becoming very pronounced, taste mild to slightly peppery; lamellae decurrent, fold-like, dichotomously forked, very narrow, often intervenose, "buff yellow" to "orange-buff" (usually a paler yellow or orange than the pileus) · stipe 4–8 cm. long, 8–18 mm. thick, solid, fleshy, whitish within, surface at first finely pruinose-tomentose and concolorous with the gills, in age glabrescent and pallid or faintly yellowish, base often staining sordid orange where bruised.

Spores yellowish ("light pinkish cinnamon") in deposits, 7–9 × 4–5 μ, ellipsoid, smooth, not amyloid; basidia 50–70 × 6–8 μ, very narrowly clavate, mostly four-spored; cheilocystidia and pleurocystidia not seen; gill trama of interwoven, narrow, equal hyphae 3–5 μ in diam. and bearing clamp connections; pileus trama homogeneous, the hyphae near the surface intricately interwoven, clamp connections abundant.

Habit, Habitat and Distribution: Single to gregarious in conifer and hardwood forests. It is common throughout the area during the rainy season. In the summer it can frequently be

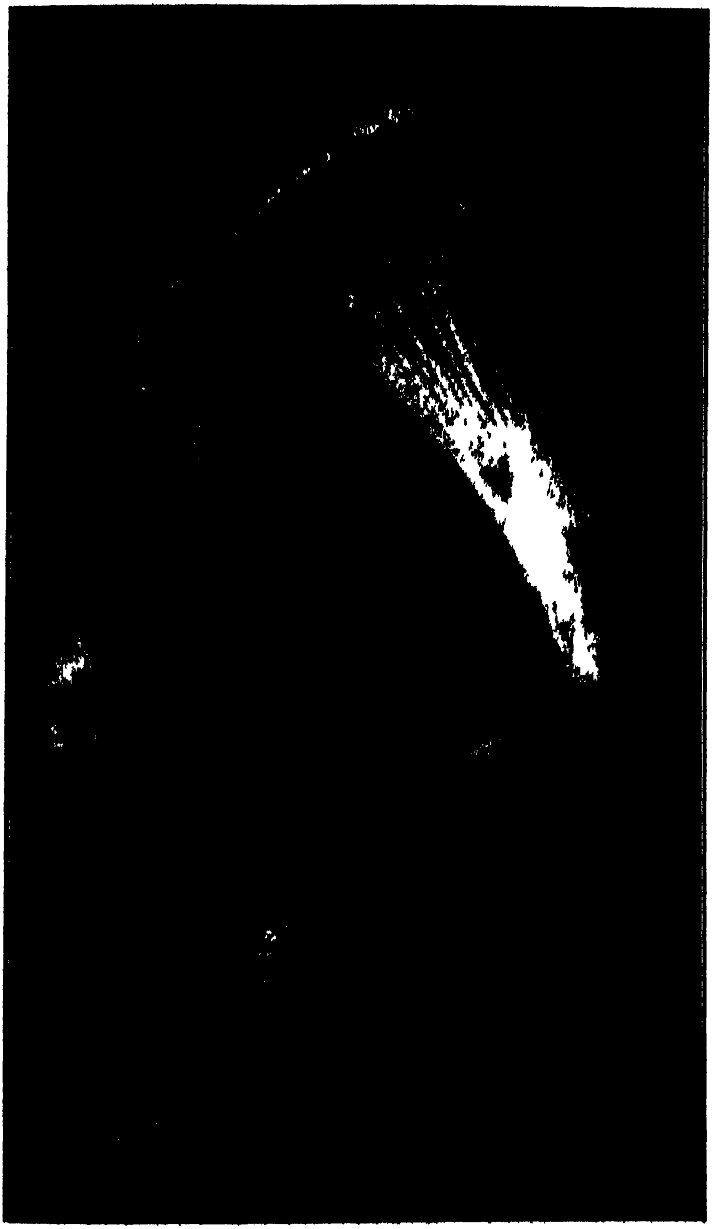

FIG. 3. *C. subalbidus.* ×1.

found around the edges of bogs and beaver ponds high in the mountains.

DISCUSSION: This species is so well known that comments about it may seem superfluous. However, the variations which occur in this region have not been given sufficient emphasis in the literature, and one who knows the fungus from our eastern states or from the illustrations in the European literature might easily fail to recognize it here. The carpophores vary tremendously in size and the degree to which the margin of the cap becomes wavy or lobed. Some who first chance on these variations without having previously collected the fungus in quantity in this area are likely to consider them as taxonomically distinct forms, varieties or even species. We do not designate them as taxonomic units at any level because of the numerous intergradations which we have observed. According to our observations the carpophores are relatively persistent and continue to enlarge as long as the weather is favorable and food is available. Material from under hemlock on Mt. Baker in Washington was indistinguishable from material collected under oak near Ann Arbor, and so it does not appear that there is any significant difference between the species as it occurs under conifers and under hardwoods. Since weather conditions along our west coast are often favorable for the prolonged growth of fruiting bodies, it is not surprising to find exceptionally large carpophores here, and in eastern United States, where, because of less prolonged periods favorable to growth and preservation of the fruiting bodies, extreme variations are not as frequently realized.

The form illustrated (FIG. 5) was "light vinaceous cinnamon" and the disc "pinkish cinnamon" when the caps were very fresh. This was caused by a fine pruinose-pubescent covering. The pilei were 3–8 cm. broad but occurred in masses 12–15 cm. broad. In some respects this variant approaches *C. amethysteus* Quél., but its spores measured only 7–9 µ long. It is one of the extreme variations encountered in the Mt. Hood area.

No attempt has been made here to list the numerous illustrations of this species in the literature. Nearly every popular mushroom book and regional flora has a picture of it.

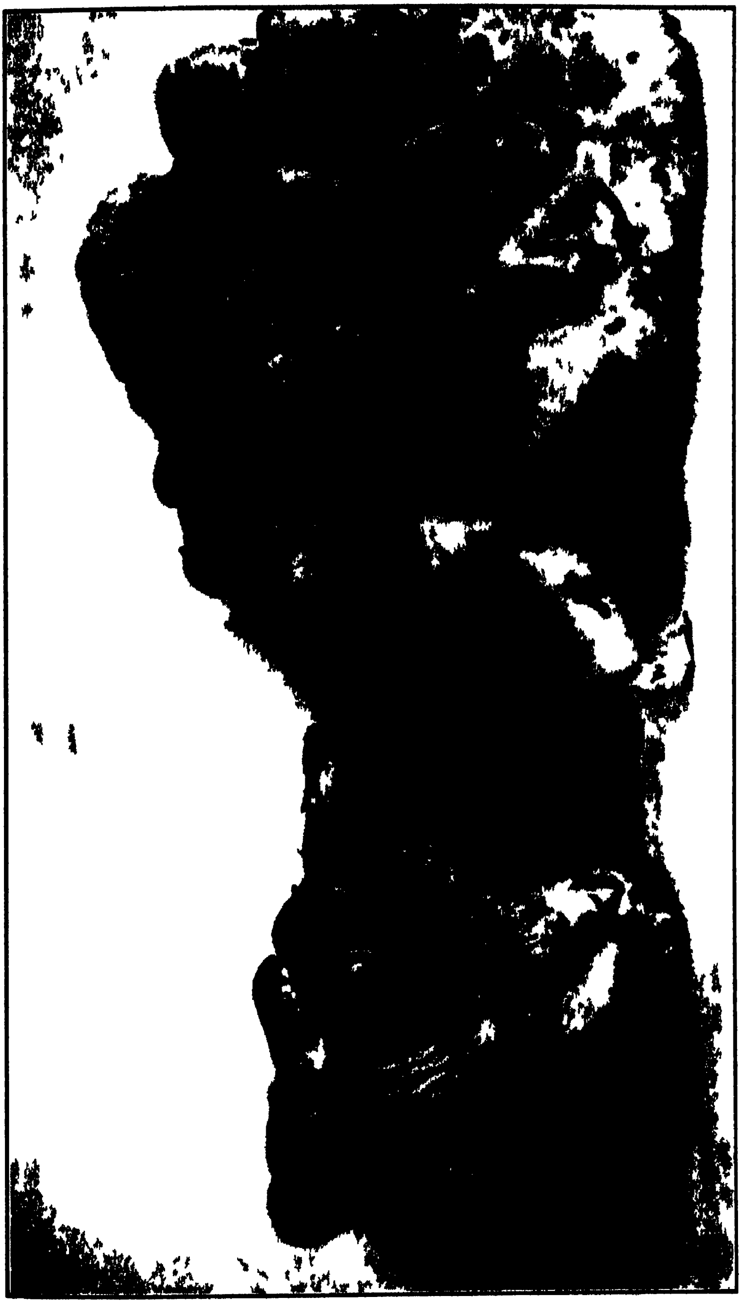

FIG 4 *Cantharellus cibarius* × 1

6. **Cantharellus Kauffmanii** Smith sp. nov. (FIGS. 5 & 6)

Pileus (4) 10–20 (35) cm. latus, planus demum late infundibuliformis, siccus, squamosus, alutaceus; lamellae luteae demum pallide alutaceae, plicosae et ramosae, decurrentes, angustae; stipes (3) 8–15 (40) cm. longus, 2–4 (6) cm. crassus, sursum expansus, solidus, firmus; sporae 12–15 × 5–6.5 μ, pallide ochraceae.

Pileus (4) 10–20 (35) cm. broad, flat with a decurved margin when very young, and then solid throughout, very soon splitting downward into the disc to form more or less rectangular segments, finally expanding to broadly vase-shaped and the columnar segments becoming separated and curved in toward the center of the disc to form long innate scales, the scales in the disc becoming worn away leaving a hollow which projects deeper and deeper into the stipe, scales continuing to form near margin as growth progresses and remaining for a time as coarse recurved scales, in age surface along the extreme margin merely split into segments which do not recurve, color of scales "clay color" to "tawny olive," flesh between them when visible whitish; flesh thick, white, firm, unchanging when cut or bruised, taste mild, odor sharp and penetrating but often absent in old caps; lamellae (hymenium) "picric yellow" young, "pinkish buff" in age, in young caps staining vinaceous brown when bruised, in the form of radiating folds at first but in age becoming merulioid with folds going in all directions and forming broad pit-like areas, very narrow, decurrent on the stipe; stipe (3) 8–15 (40) cm. long, 2–4 (6) cm. thick at point where hymenium begins, equal or narrowed downward, solid at first, becoming hollow from apex downward, whitish at first, white within, very firm and hard, often with a long prolongation extending down into the humus for long distances but not in the form of a true pseudorhiza, hymenium often descending unequal distances giving an irregular color pattern.

Spores pale ochraceous in thin deposits, 12–15 × 5–7 μ, narrowly subelliptic and in side view with a suprahilar depression, exospore slightly wrinkled, nonamyloid (rusty brown in iodine); basidia 60–80 × 10–13 μ, two- to four-spored, yellow in iodine, clavate and often with flexuous pedicels; cystidia none seen or represented by slender filaments which could be young basidia; gill trama and pileus trama of intricately interwoven hyaline hyphae lacking clamp connections and measuring 6–10 μ in diam., yellow in iodine, surface hyphae yellowish in KOH but thin-walled and smooth.

HABIT, HABITAT AND DISTRIBUTION: Subcespitose to gregarious or occasionally singly on rich humus in conifer forests. It has

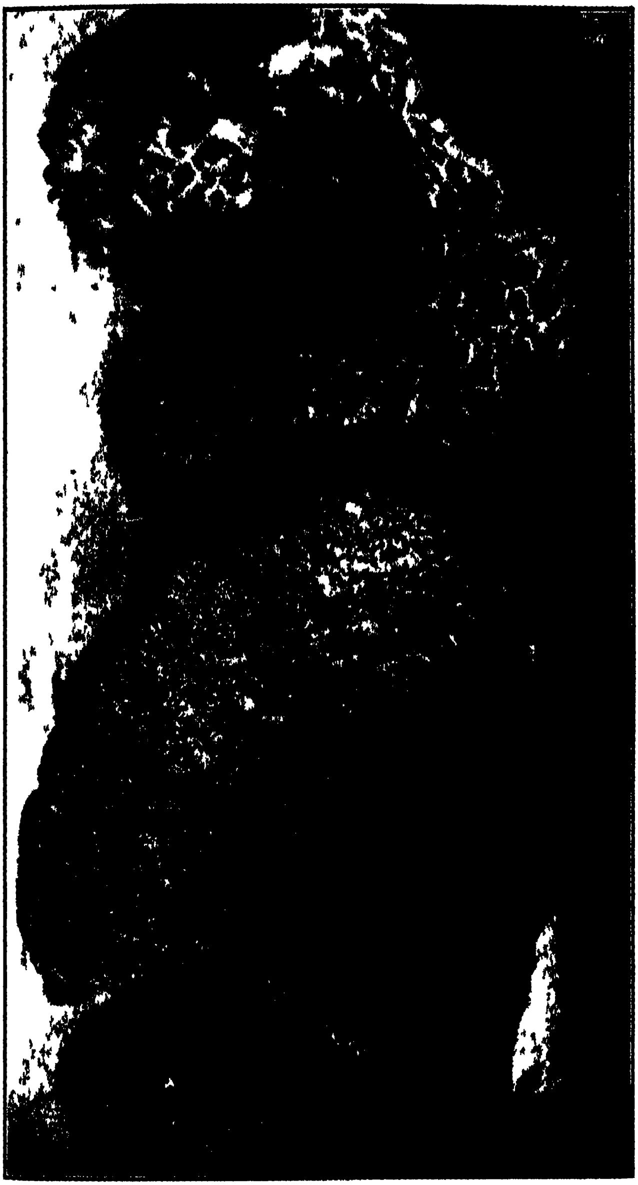

FIG 5 *Cantharellus Kauffmanii* ×⅔

been collected in the Mt. Baker Recreation Area, the Olympic National Park, and on Mt. Hood in Oregon. Kauffman collected it at Lake Quinault, Washington, Oct. 4, 1935. The above description was drawn from collection *16156-S* from near Shuksan Inn, near Mt. Baker, Washington, and is designated as the type. During warm wet seasons the species is not infrequently found in the heavy conifer forests where there is a great accumulation of humus.

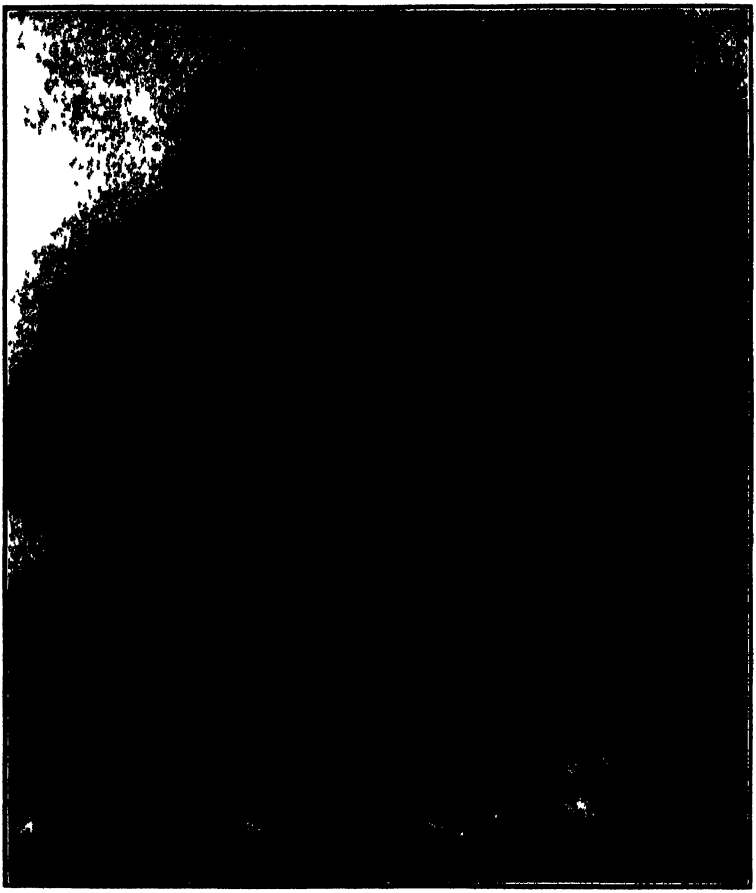

FIG. 6. *Cantharellus Kauffmanii* cap seen from above. × 1.

DISCUSSION: This is the largest *Cantharellus* known in the area if only single carpophores, not clumps, are considered, but it is not exactly a beautiful or graceful species as found in the fully matured state. It is, of course, most closely related to *C. floccosus* by virtue of the coarsely scaly pileus and the stipe which is solid at first but gradually becomes hollowed by the breaking up of the interior into scales. Occasional collections are found of fruiting bodies arrested in their development (typically small and often worm-eaten) in which the stipe remains solid and the cap is flat and covered with coarse scales. The same situation has been observed on retarded fruiting bodies growing in company with some of the largest carpophores collected. Although the striking color difference between rapidly developing fruiting bodies is the most conspicuous difference between *C. Kauffmanii* and *C. floccosus,* there is a characteristic difference in aspect which enables one to distinguish even the old worm-eaten faded carpophores of each species at a glance.

7. CANTHARELLUS FLOCCOSUS Schweinitz, Trans. Am. Phil. Soc. II. **4**: 153. 1832. f. TYPICUS (FIG. 7, center and left).

Cantharellus princeps Berkeley & Curtis, Ann. Mag. Nat. Hist. III. **4**: 293. 1859.

ILLUSTRATIONS: Peck, Mem. N. Y. State Mus. **3**: pl. 55, figs. 1–9; Marshall, N. Mushroom Book, pl. 45; Peck, Rep. N. Y. State Mus. **33**, pl. 1, figs. 18 & 20; Hard, Mushrooms, pl. 23, fig. 160, p. 201. 1908; White, Conn. State Geol. & Nat. Hist. Surv. Bull. No. 15, pl. 19; Bresadola, Iconographia Mycologica **26**, pl. 475.

Pileus 5–10 (15) cm. broad, 8–15 (20) cm. high, truncate when young, soon becoming hollowed in the center, the margin ascending but finally spreading and then the cap vase-shaped or trumpet-like, the interior (upper) surface innately scaly from the breaking up of the surface layer, the scales appressed toward the margin, more recurved in the tube and orange-yellow to reddish orange, the interspaces yellowish (scales "apricot orange" more or less); flesh moderately thick, thin in old caps, white or pallid, unchanging, fibrous, odor and taste not distinctive; lamellae foldlike and very frequently forked or anastomosing, on old caps occasionally almost poroid, decurrent almost to the base of the stipe in an irregular manner; stipe short and not sharply distinct from the pileus, solid at first but becoming hollow as the cavity in the pileus deepens, whitish and unpolished, tapered more or less to the base which is usually deeply sunken in the humus.

Spores ochraceous in deposits, 12–15 × 6–7.5 μ, narrowly ellipsoid, slightly yellowish in KOH, ochraceous tawny in iodine, exospore slightly wrinkled; basidia 52–60 × 10–12 μ, clavate, hyaline in KOH, yellow in iodine; cystidia none seen; gill trama interwoven and not clearly distinct from that of the pileus, hyaline in KOH, yellow in iodine, no clamp connections present.

HABIT, HABITAT AND DISTRIBUTION: During the late summer and fall this is a common species in the higher mountains, and with the onset of the rainy season may be expected in most any conifer area from sea level to timberline. The carpophores may occur singly, gregariously or subcespitosely, often at higher elevations with two or three developing from a common stipe. It is one of the common fungi in the area and during moist warm weather attains its maximum size and brilliancy of coloration.

DISCUSSION: The fruiting bodies of this species are very persistent with the result that one frequently finds it in the faded condition and then an inexperienced collector might confuse it with *C. Kauffmanii.* It lacks the pungent odor of *C. Kauffmanii,* and this will often help to distinguish collections of carpophores which are past their prime. Fresh material which is still developing vigorously is readily identified by the orange to orange-red color of the scales. As found throughout the area concerned, there is considerable difference in stature to be noted on collections made in different seasons and at various elevations, but we have not separated out taxonomic units other than forms on the basis of whether the fructification becomes vase-like and the stipe deeply hollowed. The publication of this paper was withheld for a number of years in order to study these variations carefully. During the seasons of 1944 and 1946 extensive collecting was carried out along the crest of the Cascades between Mt. Hood and Mt. Jefferson. Many collections with solid stipes and somewhat truncate pilei were found along with some from relatively warm, wet areas which had deeply hollowed stipes. It appears to us that these differences can be satisfactorily explained by the difference in growth rate shown by carpophores from high elevations as compared with those from lower areas. In f. *typicus* the stipe is solid at first but the cap expands fairly rapidly under average conditions so that the stipe soon becomes hollowed by the breaking up of the stipe tissue into soft scales which soon weather into a more or less floccose condition. The extreme in this type of development, is found on fruiting bodies from the redwood forests along the coast of California. The other extreme is an alpine type often with several pilei arising from a common stipe as in *C. Bonarii,* but with larger caps, solid stipes, well formed fibrous and often very persistent scales (which usually are weakly tinted yellow-orange in color). Groups of these caps have been observed to change but little in a two-week period. Since high altitudes in this region do not favor either decay or insect damage to carpophores, those of this species very likely develop over a period of at least a month, particularly during cool dry years. Figures 7, 8 and 9 show three of these variants. For an illustration in color of f. *typicus* see Smith.[1] Since the extreme variants are fairly constant in the areas where the conditions producing them are constant, we have given them the ranking of formae and distinguish them as follows from f. *typicus.*

(a) C. FLOCCOSUS f. **rainieriensis** f. nov. (FIGS. 9 & 10). A typo differt: Pileus squamosus; stipes solidus vel sursum excavatus. Specimen typicum legit C. Frank Brockman, Mt. Rainier National Park, Wash.; in Mt. Rainier National Park Herbarium conservatum.

The scales of the pileus vary from the condition shown here to that found in f. *typicus.* The subalpine form is essentially a short-stiped slow growing form of heavy stature, and in which the stipe seldom becomes deeply hollowed. The configuration of the hymenium is more frequently like that of *C. Kauffmanii* than is that of any of the other forms. Although essentially alpine to subalpine in distribution, during cold dry years one can expect to find it at relatively low elevations and in such seasons it intergrades imperceptibly with f. *typicus.*

Cantharelli with solid stems which do not readily become hollow were first called to our attention by C. Frank Brockman in 1930 while he was naturalist at Mount Rainier National Park. His

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[1] Mushrooms and other fleshy fungi in their natural habitats. Illustrated with stereo-kodachromes. Sawyer's Inc., Portland, Ore. In press.

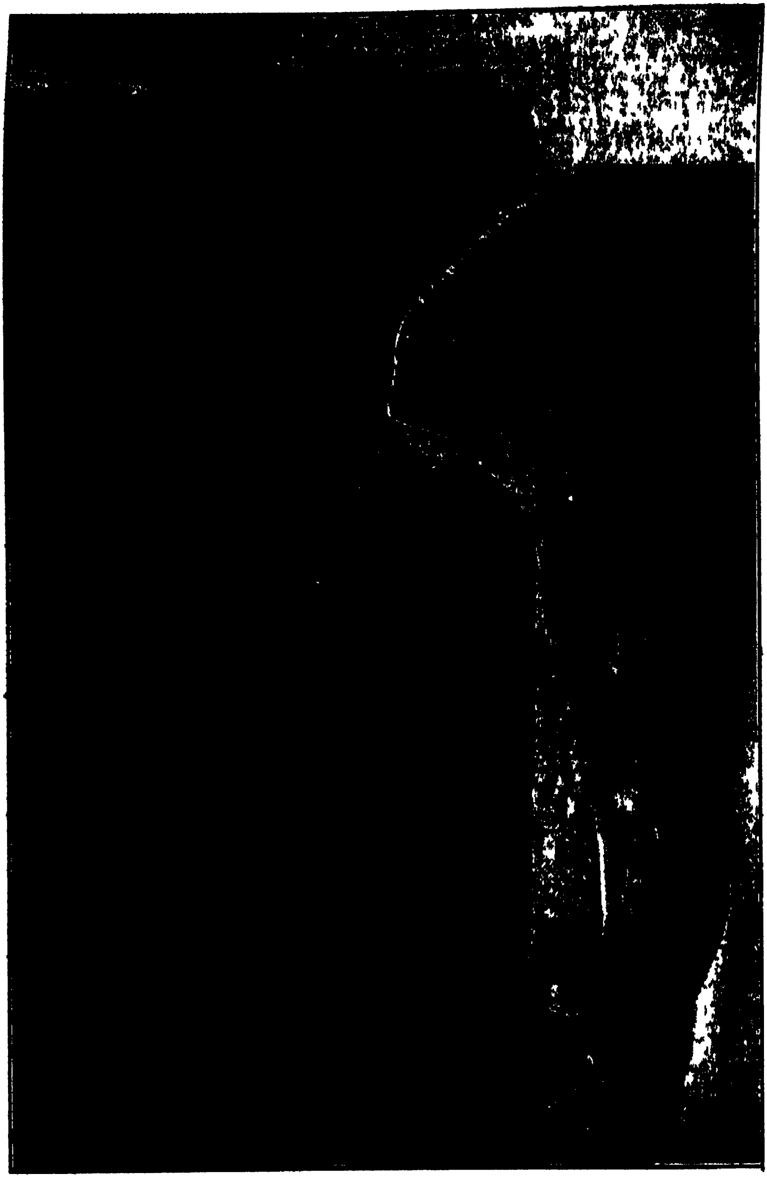

Fig 7. Left: *C. floccosus* f. *excavatus* (16 × 9 cm.). Right and Center: *C. floccosus* f. *typicus*.

original collection constitutes the type and is on deposit in the herbarium of the Park at Longmire, Washington. More recently the form was collected along the crest of the Cascades between Mount Hood and Mount Jefferson in Oregon by Smith and photographs obtained

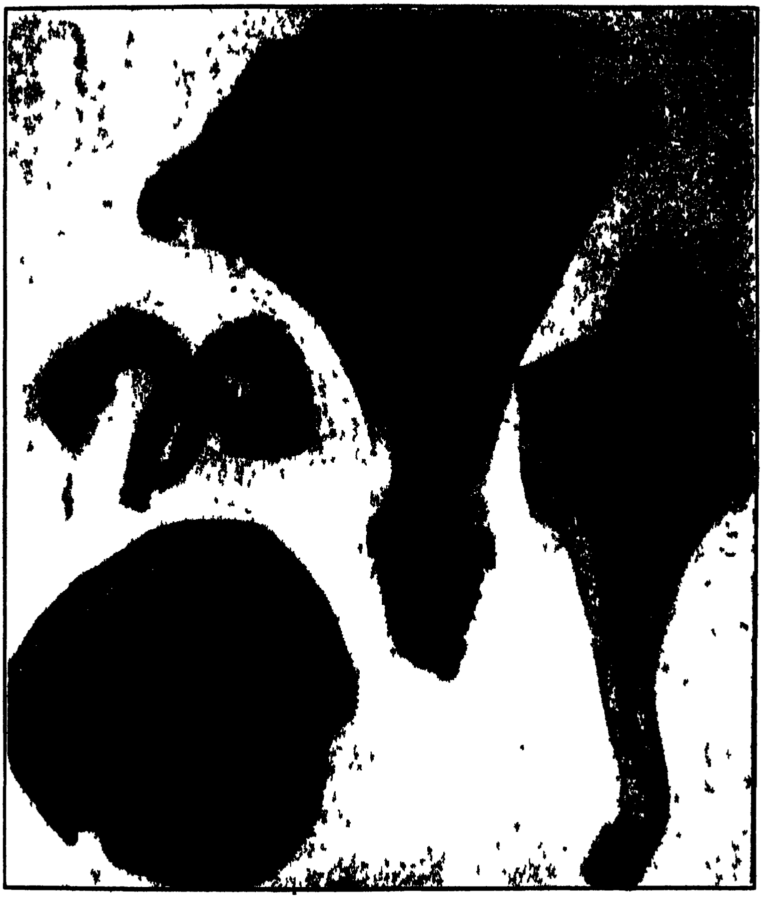

FIG. 8 *C floccosus* f *excavatus* × ⅛

(b) C FLOCCOSUS f. **Wilsonii** f nov. (FIG. 11) A typo differt. Stipes solidus, pileus squamosus, truncatus. Specimen typicum in Morse Coll. et in Herb. Univ. of Mich. conservatum; legit prope Wright's Lake, Sierra Nevada Mts., Calif., 6767 ft. elev. Oct, 1937.

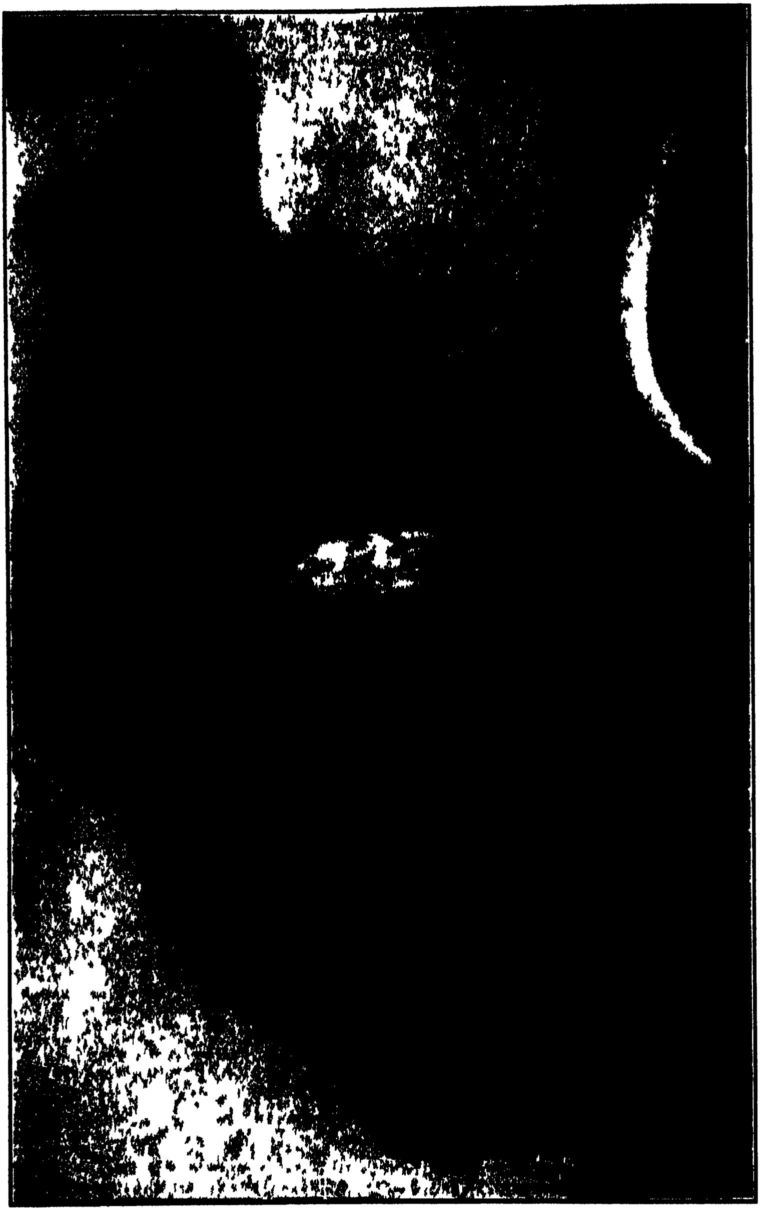

FIG 9 *C floccosus* f *rainieriensis* × 1

This form is paler than either f. *typicus* or f. *rainieriensis* but this is not so important as the solid stipe and nearly flat scaly pileus. Even when dried the stipe tissue (FIG. 11) does not collapse as in most other forms. Actually this form may represent a distinct species between *C. floccosus* and *C. Bonarii,* but so far we have seen only the one collection and it does not seem advisable to establish a species in this group without a detailed knowledge of all stages of development.

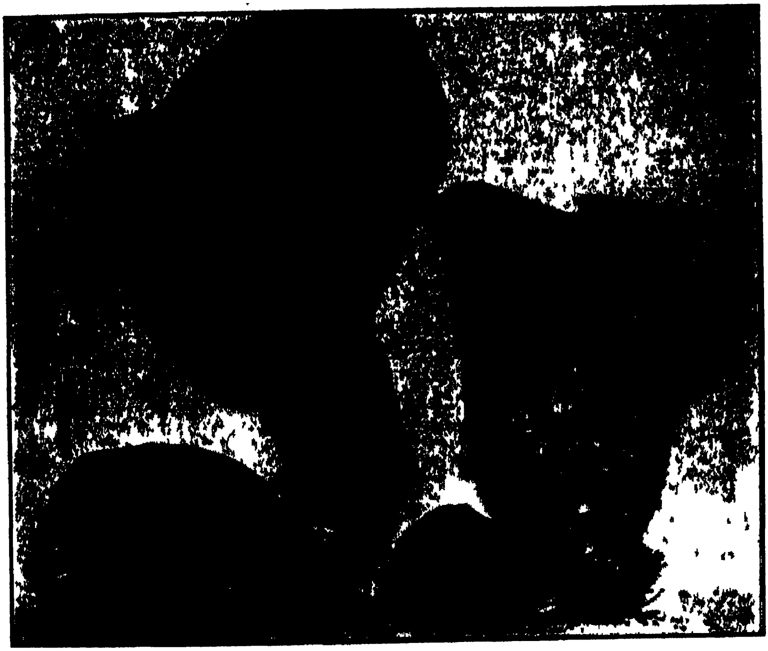

FIG 10. *C. floccosus* f *rainieriensis* × ¾.

(c) C. FLOCCOSUS f **excavatus** f. nov. (FIG. 7, left, and FIG 8). A typo differt: Pileus profunde excavatus, floccosus; stipes deorsum solidus demum cavus. Specimen typicum in Morse Coll. conservatum, legit prope Eureka, Calif., 1930, Richardson

This form is the largest of any in the species, and appears to be a robust, warm weather form characteristic of the redwood belt. As a rule the scales are not well developed, the cap being merely floccose to fibrillose. The colors are not as bright in

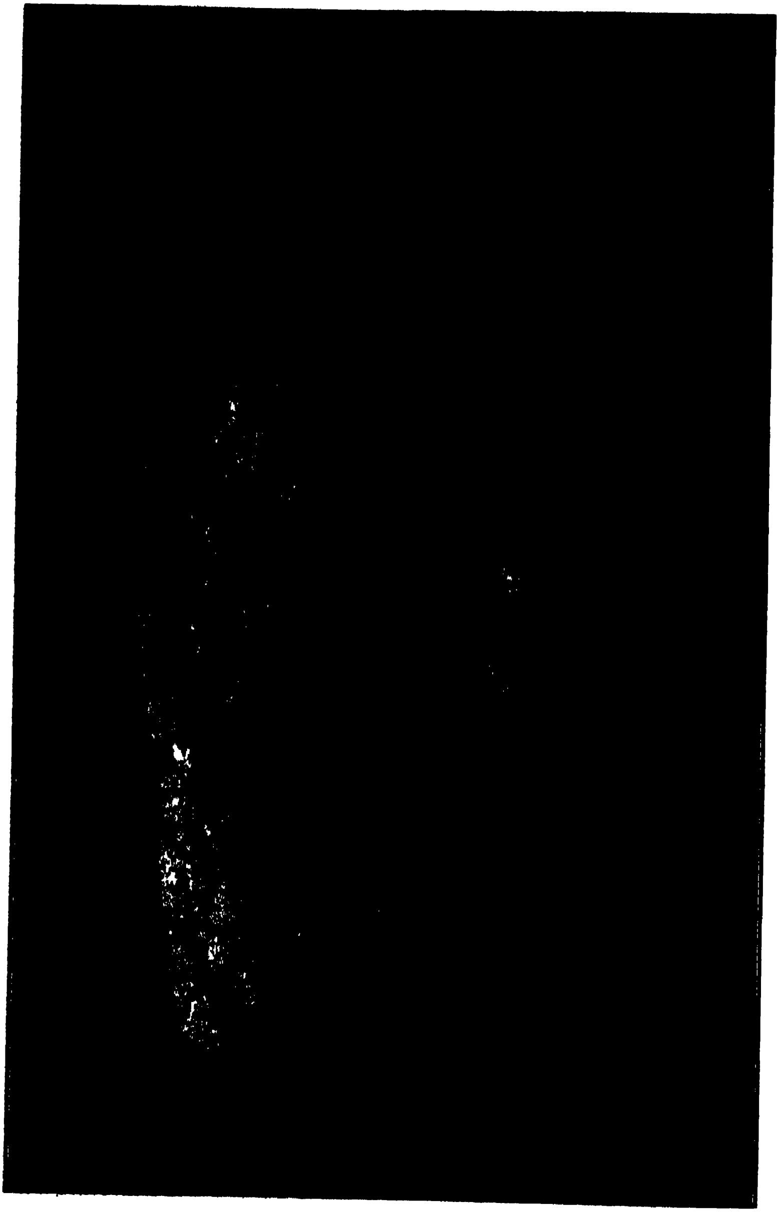

FIG. 11. *C. floccosus* f. *Wilsonii.*

most collections, being more yellow than red. The illustration of dried fruiting bodies (FIG. 8) is included to show the extreme difference between this form and f. *Wilsonii*.

8. CANTHARELLUS BONARII Morse, Mycologia 22: 219. 1930.

ILLUSTRATIONS: l.c. pls. 24 & 25.

Pileus 3–7 cm. broad, fleshy, margin involute at first, regular in young carpophores, spreading and undulating or lobed at maturity, soon depressed at the center, surface broken into thick floccose more or less erect scales which fill the central depression, scales orange at the tips blending to lemon yellow at the base and giving the entire cap an orange-yellow color, fading to near "pinkish buff" in drying; flesh white, firm, tapering to margin, relatively thin, odor none, taste not recorded; lamellae obtuse, very narrow, in the form of radially disposed subdistant decurrent folds or merulioid (subporoid from anastomoses or connecting veins), primary folds sometimes decurrent half the length of the stipe, color milk-white when fresh, sordid cremeous to brownish when dried; stipe 2–4 cm. long, 10–15 mm. thick, solid, glabrous, white, enlarged upward into the pileus, mostly fused with other stipes (up to 13 from a common base), the entire cluster 5–7 cm. tall, many undeveloped fruiting bodies sometimes present in the large clusters.

Spores slightly yellowish as revived in KOH and viewed in groups, individual spores hyaline, probably yellowish in deposits, 10–12 (14) × 5–6 μ, subellipsoid, smooth to slightly roughened (outer wall slightly wrinkled), apiculate, ochraceous tawny in iodine; basidia two- to six-spored, hyaline in KOH, 44–70 × 7–8 μ, narrowly clavate with flexuous pedicels; no pleurocystidia or cheilocystidia present; gill trama of interwoven hyaline hyphae without clamp connections; pileus trama hyaline in KOH, the hyphae similar to those of the gill trama.

HABIT, HABITAT AND DISTRIBUTION: Closely gregarious to cespitose, partly hidden in deep humus under pine and fir, Sierra Nevada Mountains, California. It usually fruits in the spring.

DISCUSSION: This species is clearly related to *C. floccosus* but distinct by the smaller size of the fruiting bodies and the clustered manner of growth. A very distinctive feature is the large number of undeveloped fruiting bodies in some of the clusters and the tendency for a number (up to 13 carpophores) to be borne on a common base (l.c. pl. 24). Although *C. floccosus* is a common fungus northward in the mountains of this region and one we have studied in great detail, we have never observed forms which intergraded with *C. Bonarii*. In the reaction of the spores in iodine, lack of clamp connections on the hyphae of the flesh, and in the character of the outer spore wall, the two are very similar.

9. **Cantharellus Wilkinsae** Morse, sp. nov. (FIG. 12)

Fructificationes 4–11 cm. altae, 2–4 cm. latae; pileus anguste infundibuliformis, saepe 3–6 lobatus, siccus, fibrillosus demum squamosus, pallide alutaceus, durus; lamellae anguste plicosae, decurrentes, pallide luteo-alutaceae; stipes sursum expansus, brevis, durus, solidus, pallidus; sporae 14–18 × 6-7 μ, leves.

Fruiting body 4–11 cm. high, 2–4 cm. broad at apex, not distinctly differentiated into pileus and stipe, apex with a flaring margin causing carpophores to be narrowly trumpet-shaped at maturity, margin soon splitting into 3–6 lobes which become decurved or may remain uplifted, the upper surface (inner surface of the trumpet) dry and fibrillose, the outer layer of it soon splitting into scales which curve inward toward the tube as in *C. floccosus* and eventually become worn away, or surface merely fibrillose-roughened and gradually glabrescent, color more or less sordid cinnamon buff and unchanging when dried; flesh hard and almost woody in old carpophores, odor and taste not recorded; hymenium smooth to longitudinally wrinkled or in the form of gill-like folds near the recurved segments, hymenium extending downward about half the length of the trumpet, sordid cream color and drying to pale sordid alutaceous; stipe not distinct from remainder of fruiting body and usually represented by the narrowed portion of the carpophore below the hymenium, solid, hard, semi-woody when dried, whitish throughout, base covered by white mycelium causing debris and dirt to adhere to it, clusters arising from a mass of underground fungous tissue.

Spores subellipsoid to slightly inequilateral, 14–18 × 6–7 μ, smooth, hyaline in KOH, yellowish in iodine or pale tawny if groups are viewed, the wall minutely punctate as seen mounted in iodine; basidia 72–90 × 9–12 μ, four- to eight-spored, yellowish in KOH (hymenium yellowish orange); pleurocystidia and cheilocystidia not differentiated; gill trama and pileus trama similar, hyaline in KOH, of very compactly interwoven hyphae 5–12 μ broad, yellowish in iodine, thin-walled, no clamp connections present.

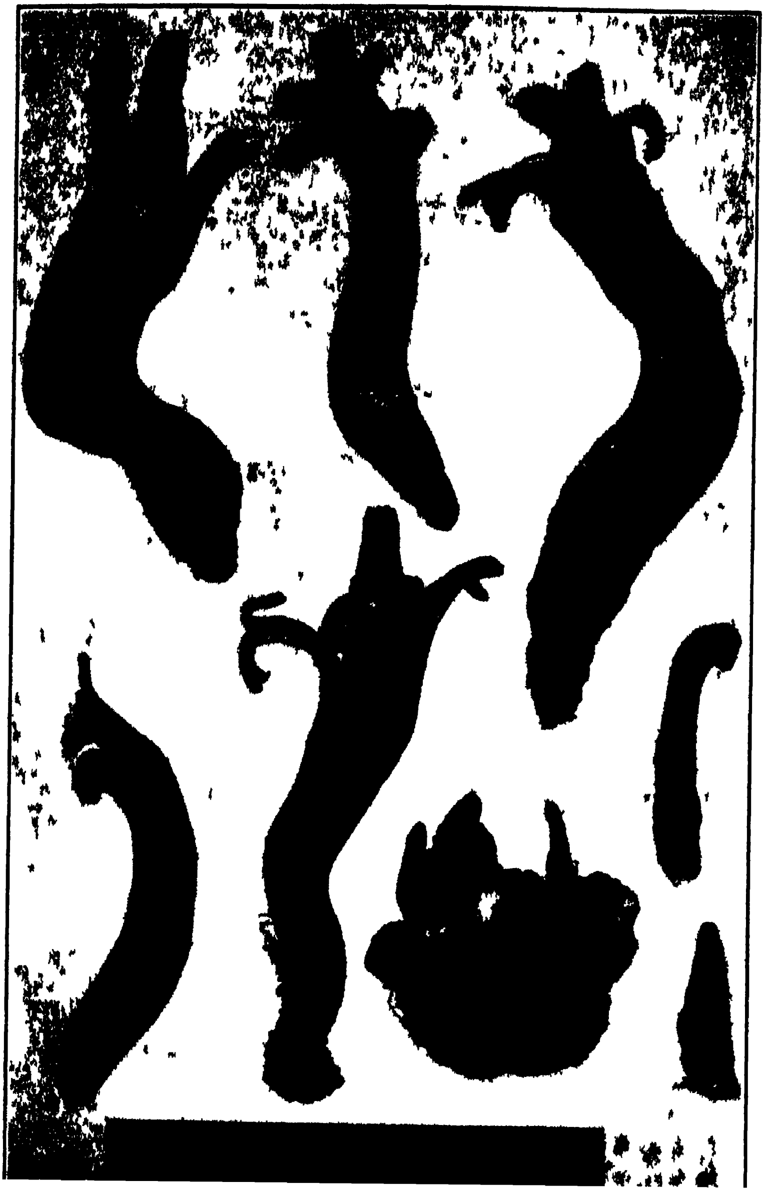

FIG 12 C *Wilkinsae*

HABIT, HABITAT AND DISTRIBUTION: Clustered to gregarious in the vicinity of red fir, El Dorado National Forest, California, elev. about 6500 ft. The species is known only from the type collection. The fruiting bodies in some groups were so close to fir roots that they appeared to come from them but no real attachment was found.

DISCUSSION: This species is named in honor of Miss Edith Wilkins of Sacramento, California, who first discovered it near the Bryant Creek Tract in the El Dorado National Forest. Although the specimens were collected after a light fall of snow, it is obvious from the nature of the carpophores that they develop slowly and persist for a long time. Hence the species is hardly to be regarded as one of those which typically fruit late. The photograph illustrates all stages of development. In our estimation this fungus is properly classified in the same group as *C. floccosus* to which it is related by its microscopic characters, but represents a distinct species close to *C. Bonarii*. It is amply distinct from the latter by its larger spores, different colors and stature and much harder consistency.

10. CANTHARELLUS TUBAEFORMIS Fries, Syst. Myc. 1: 319. 1821 (FIG. 13).

Pileus 1–3 (5) cm. broad, convex to plane or broadly depressed and with an arched incurved margin at first, margin finally spreading or uplifted and becoming crenate to variously lobed, occasionally somewhat funnel-shaped in age, usually not perforated in the disc at first but frequently becoming so in age, surface moist and more or less uneven, at times with radial ridges terminating in scabrous points, sometimes quite rough, sometimes practically glabrous, moist, color "Saccardo's umber" to "sepia" (dark sordid yellowish brown), at times more or less sordid ochraceous; flesh thin and membranous, fragile, yellowish to avellaneous, odor and taste not distinctive; lamellae decurrent, narrow and foldlike, subdistant, dichotomously forked, yellowish gray to "avellaneous" (grayish brown), often pale drab in age; stipe 3–6 cm. long, 3–7 mm. thick, stuffed but becoming hollow and flabby, subequal, often compressed or furrowed, glabrous, dark to pale ochraceous above, usually whitish at the base.

Spores white to creamy white in thick deposits, (8) 9–11 × 5.5–7 μ, ellipsoid to ovoid, smooth, not amyloid (pale ochraceous tawny

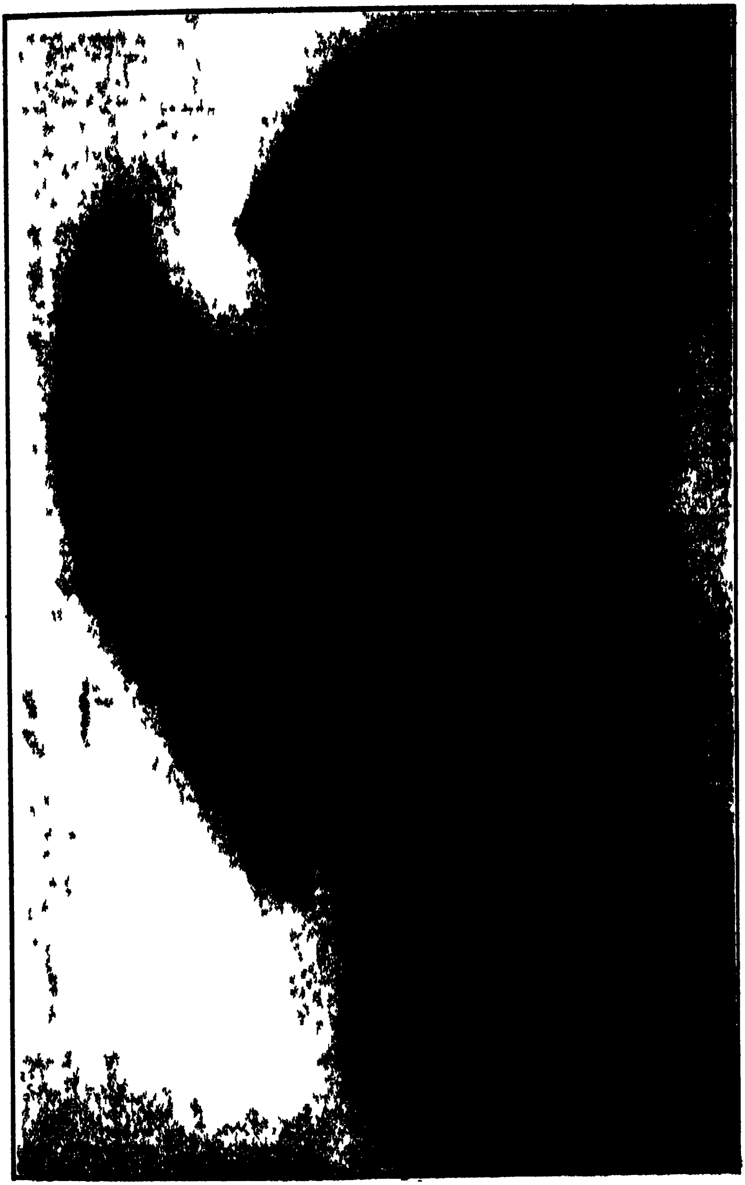

FIG 13 *Cantharellus tubaeformis* ×1

in iodine); basidia 64–82 × 9–11 μ, clavate, flexuous toward the base, two- and four-spored, pale yellowish brown in iodine, content mostly of oil globules when revived in KOH; pleurocystidia and cheilocystidia none; gill trama interwoven, the hyphae 6–10 μ in diam. and hyaline in KOH, clamp connections present; pileus trama interwoven, of hyaline hyphae 6–12 μ in diam., the hyphae on the surface yellowish brown but otherwise not differentiated from the flesh proper, clamp connections abundant.

HABIT, HABITAT AND DISTRIBUTION: On wet soil, often along streams or near springs or in bogs under conifers. It varies from cespitose to gregarious. Its abundance and distribution in the area remain to be established. It has been collected along the East Fork, Salmon River, Mt. Hood, Oregon, at an elevation of about 3800 ft. (*S–19149*).

DISCUSSION: The nomenclature as well as the concept of this species is in a state of confusion. If one adheres strictly to the rules of nomenclature the name *C. tubaeformis* must be used by those who consider this and *C. infundibuliformis* to be synonyms. The carpophores of the various species in this group are so variable in color, so similar in aspect and in having the disc perforated in old specimens that we have been unable to arrive at satisfactory species concepts with them as a basis. In the American literature we find that *C. infundibuliformis* is said to have spores which are yellowish in a deposit whereas those of *C. tubaeformis* are white to creamy white. In the western United States we find collections which fall into these two categories, and we are recognizing the two species on that basis. It should be pointed out, however, that European authors are not in agreement on this point and one encounters the statement (see Rea, Brit. Basidiomycetes, p. 544) that both have white spores. We wish to emphasize that we are here drawing our concepts along the lines laid down by previous American workers because they seem to us to have hit upon the best diagnostic character--the one which clearly separates two taxonomic units at the species level in this complex. A third species, *C. lutescens*, has recently been studied from collections made near the Univ. of Michigan's Biological Station at Douglas Lake, Michigan. Its spore deposit is "ochraceous salmon" and its gills are not well formed. There are still other elements in this complex which need critical study.

11. CANTHARELLUS INFUNDIBULIFORMIS Fries, Epicr. Syst. Myc. p. 366. 1838.

Pileus 15–30 mm. broad, convex with a flattened or slightly depressed disc at first, soon deeply and sharply depressed and then becoming perforated, surface moist and uneven, with a yellow ground color on which are dispersed minute grayish streaks which may terminate in minute scales, color-effect about "Brussels' brown" in young caps, yellower in age; flesh thin, dull yellow, odor and taste not distinctive; lamellae pale yellow ("warm buff"), well formed and dichotomously forked, intervenose, narrow, decurrent, subdistant, edges obtuse; stipe 5–8 cm. long, 4–9 mm. thick, hollow, fleshy-fragile, glabrous, "light orange yellow" when young, paler and duller in age, sometimes a gray cast present near apex, base pale yellow.

Spores pale yellow in mass and yellowish when fresh material is mounted in water, bright yellow in iodine but fading to nearly hyaline on standing an hour, 9–11 × 7–8.4 μ; basidia up to eight-spored, yellowish orange in iodine in sections of dried material, paler after standing; no cystidia seen; subhymenium much branched, pale yellow in iodine; flesh of cap and gill trama compactly interwoven and sordid yellow to bister (thick sections) in iodine; cuticle not differentiated, clamp connections present on most hyphae of cap and lamellae.

HABIT, HABITAT AND DISTRIBUTION: Very common on conifer logs which have been reduced almost to humus. It may grow single, gregarious or cespitose, and fruits during the fall rainy season at low as well as high elevations.

DISCUSSION: As pointed out under *C. tubaeformis* these two differ primarily in the color of the spore deposit. No chemical differences have yet been found which seem to be worthy of mention. The iodine reaction of the spores is variable, being a bright yellow to almost pale ochraceous tawny in some collections, but if left standing in the medium they become paler to nearly hyaline. We do not insist that we have described here the *Cantharellus infundibuliformis* of European authors, but, as mentioned previously, seek to establish the existence of two distinct species in our *Cantharellus* flora. The name *C. infundibuliformis,* if the rules of nomenclature were strictly applied, would automatically become a synonym of *C. tubaeformis* (see Lange, Flora Agaricina Danica 5: 85). This would appear to leave the yellow spored species here treated as *C. infundibuliformis* without a name unless some little used name such as *C. sphaerosporus* Pk. were brought back into use. Here, however, we encounter the same difficulty which makes a decision on any name in the group difficult. The essential data are not given in the original description and cannot be obtained now from the type. In view of this confused situation we have decided to follow the concepts as they were given by Kauffman in his Agaricaceae of Michigan.

UNIVERSITY OF MICHIGAN,
ANN ARBOR, MICH.
CALIFORNIA MYCOLOGICAL SOCIETY,
BERKELEY, CALIF.

NEW AND INTERESTING SPECIES OF CORDYCEPS[1]

E. B. MAINS

(WITH 3 FIGURES)

In continuation of investigations concerning the genus *Cordyceps,* collections have been obtained from various sources which furnish additional information concerning the genus.

CORDYCEPS WASHINGTONENSIS

In 1941 while located at Mount Baker, Washington, with A. H. Smith, the writer obtained several collections of a *Cordyceps* on lepidopterous larvae along the trails near Baker Lake. At the time, it was thought that a form of *Cordyceps militaris* (Fr.) Link had been obtained. The clavae resembled those of that species, differing principally in color which was sulphur yellow (R)[2] to Pinard yellow (R) instead of the orange or orange yellow of *C militaris.* However, a study of the specimens has resulted in finding that they differ in several important microscopic details from that species. Apparently they belong to a new species which is described as follows.

Cordyceps washingtonensis sp. nov. (FIG. 1). Clavis fusoideo-cylindraceis vel anguste clavatis, 1.5–3.0 cm. longis, 2–6 mm. latis, sursum sulphureis, stipitibus albidis; peritheciis immersis in molle stromate denique prominentibus, sulphureis vel flavis, ovoideis, 480–644 × 252–386 μ; ascis cylindraceo-clavatis, deorsum attenuatis, 300–418 × 3–3.5 μ; ascosporis anguste cylindraceo-clavatis, 80–110 × 1–1.5 μ, non frangentibus.

Ex pupis lepidopterarum. Specimen typicum, Baker Lake, Washington, 1 Sept., 1941, E. B. Mains (*6185*), in Herb. Univ. Mich. conservatum.

Clavae fusoid-cylindric to narrowly clavate, 1.5–3.0 cm. long, 2–6 mm. wide, in the upper part sulphur yellow (R) when young becoming Pinard yellow (R) when mature, the stipes whitish; perithecia at first embedded in a soft whitish stroma, finally pro-

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[1] Paper from the Department of Botany and the Herbarium of the University of Michigan.

[2] Colors designated (R) are from Ridgway, Color standards and color nomenclature.

jecting up to one-half of their length, at first sulphur yellow (R) becoming Pinard yellow (R) upon maturity, ovoid, 480–644 × 252–386 μ; asci cylindric-clavate, attenuated below 300–418 × 3–3.5 μ; ascospores narrowly cylindric-clavate, narrowed below, 80–110 × 1–1.5 μ, not breaking into segments.

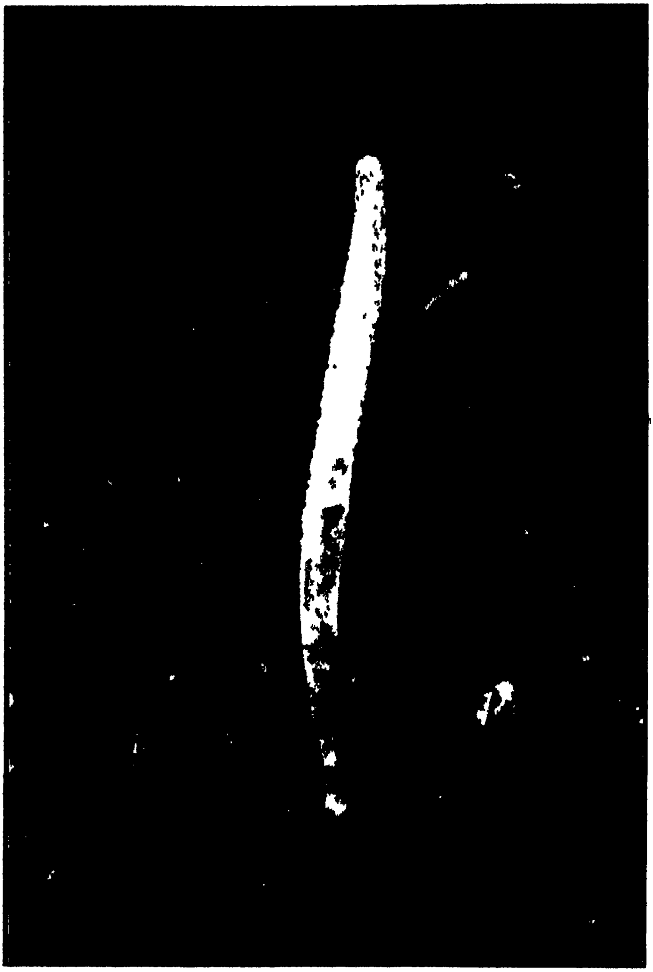

FIG. 1. Clava of *Cordyceps washingtonensis.* × 3.

From buried lepidopterous larvae, Baker Lake, Washington, September 1, 1941, E. B. Mains (*6185,* **type**); Sept. 2, 1941,

E. B. Mains (*6204*); Sept. 5, 1941, E. B. Mains and A. H. Smith (*6232*).

The description with the exception of the microscopic characters was made from the freshly collected specimens. The dried specimens are 1.1–2.5 cm. long and 1–4 mm. wide. They are sordid white except for the perithecia which are honey yellow. The soft white stroma in which the perithecia are embedded dries down to a very thin subiculum covering only the lower portions of the perithecia and leaving them almost superficial. In this respect it resembles *C. militaris*. Although it is similar to that species in general morphology it differs not only in color but in the types of asci and ascospores. *C. militaris* has cylindric asci and filiform ascospores which break up into one-celled fragments at maturity.

CORDYCEPS OLIVASCENS

Among the collections of fungi received from Dr. R. P. Burke of Montgomery, Alabama, in 1942, was a very interesting specimen of *Cordyceps*. It consisted of a single clava 4 cm. long with a cylindric head 1.5 cm. long and 2.5 mm. thick and the remains of an insect of which only chitinous fragments were left. The dried specimen is citrine-drab (R). Dr. Burke's notes give the color of the fresh specimen as olive buff (R) to deep olive buff (R). This appears to differ from other olivaceous species and the name *Cordyceps olivascens* is proposed for it.

Cordyceps olivascens sp. nov. Clava 4 cm. longa, olivacea, capitulo cylindraceo, 1.5 cm. longo, 2.5 mm. lato, stipite 1-2 mm. lato; peritheciis recte immersis, conoideis, 900–1200 × 240–374 μ; ascis anguste cylindraceis, 480–600 × 4–6 μ; ascosporis filiformibus, multiseptatis, frangentibus, articulis oblongis, 3–4 × 1 μ.

Ex insecto. Specimen typicum, Fusihatchie, Alabama, R. P. Burke, 21 Junii, 1942, in Herb. Univ. Mich. conservatum.

Clava 4 cm. long, the fertile portion cylindric, 1.5 cm. long, 2.5 mm. wide, citrine drab (R), punctate due to the slightly projecting ostioles of the perithecia, the stipe 1 mm. thick above, 2 mm. below, dark olive (R); perithecia conoid, 900–1200 × 240–374 μ, embedded with the longitudinal axis at right angles to the surface of the head; asci narrowly cylindric, 480–600 × 4–6 μ; ascospores filiform, multiseptate, soon breaking into oblong fragments 3–4 × 1 μ.

Associated with the remains of an unidentified insect in rotten wood humus under a log, Fusihatchie, Alabama, June 2, 1942, R. P. Burke (type).

The above description was made from the dried specimen. According to the notes of Dr. Burke the clava when fresh was lighter in color, olive buff (R) to deep olive buff (R). The stipe was almost white at the base and it was glabrous, finely striate and tubular. The insect was badly disintegrated, only fragments of the body wall, head and legs remaining.

There are a few species of greenish or olivaceous *Cordyceps* Of these, *C. olivacea* Rick, *C. olivaceo-virescens* P. Henn. and *C joaquiensis* P. Henn. are nearest to *C. olivascens*. *C. joaquiensis* was based by P. Hennings (3) upon a collection made by E. Ule in Brazil. It is described as having single or cespitose, fusco-olivaceous clavae, 6–8 cm. long. The asci are given as 150–200 × 4–4.5 μ. It is therefore a much larger species than *C. olivascens* and has smaller asci.

Cordyceps olivaceo-virescens was described by P. Hennings (2) from a collection from Brazil as clavate, furcate, olivaceo-virescent, with a fusoid or cylindric head 1.5–2 cm. long and 2–3 mm. thick and a stipe 3–3.5 cm. long and 1.5–2 mm. thick. The perithecia are given as semi-immersed, ovoid and 200 × 150 μ and the asci as cylindric, 120–160 × 3.5–4 μ, with filiform, multiseptate ascospores, 0.3–0.5 μ thick. Petch (7) casts some doubt on the color stating that it is "due, at least in part, to a covering of conidia of *Aspergillus* or *Penicillium*." He states that the perithecia are immersed and are oblique as in *C. brasiliensis* for which he considers it synonymous.

Cordyceps brasiliensis was described by P. Hennings (1) from a collection from Brazil as 5 cm. long, 2 mm. thick, pallid and furcate at the apex. The perithecia are given as oblong, 0.7–0.8 mm., free or adnexed and the asci as 220–290 μ long and 4–5 μ wide. Petch (7) states the the perithecia of the type are immersed and oblique. Since it was preserved in alcohol as an exhibition specimen he was not able to obtain additional details. The pallid color was doubtless due to its preservation in alcohol and the original color therefore is uncertain. It seems questionable therefore that the name *C. brasiliensis* should be applied to *C. olivaceo-virescens*.

C. olivaceo-virescens has been reported from China by Teng (12). He describes the clavae as olivaceous green, 4–6 cm. long, solitary to gregarious and arising from a dense greenish mycelium which almost entirely covered the host, a small Coleoptera. The stipe is simple or branched, 2.5–4.5 cm. long and 1.5 mm. thick, and the head cylindric, 15 × 2–3 mm. The perithecia are obliquely immersed, ovate, 550–600 × 300 μ and the asci 450 × 4 μ. As Teng notes, the size of the perithecia and asci differs considerably from those given by Hennings. He points out that if Hennings' measurements were obtained from transverse sections of the head, they would be erroneous.

Cordyceps olivacea Rick was proposed by C. G. Lloyd (4) for a collection sent by J. Rick from Brazil. He published two illustrations and stated that it resembled *C. militaris* except that it was smoother and differed in color which was olive when fresh (4, p. 1308). He suggested that it might be the same as *C. olivaceo-virescens*. Petch (7) considers it a synonym of *C. brasiliensis* along with *C. olivaceo-virescens*. Through the kindness of J. A. Stevenson the specimen of *C. olivacea* in the Lloyd Herbarium at Washington was loaned for study. This consists of one clava which now shows no trace of green. The information derived from this specimen follows:

Cordyceps olivacea Rick. Clava club-shaped, 5 cm. long, with the fertile portion 2 cm. long, 4 mm. thick, dull yellowish brown, punctate due to darker colored ostioles; stipe 3 cm. long, 1.5 mm. thick; perithecia entirely embedded, oblique to the surface of the clava, flask-shaped, 600–780 × 300–360 μ; asci cylindric, 450–480 × 4–5 μ, the ascospores nearly as long as the asci, 1 μ thick, multiseptate, with the septa 5–15 μ apart. Lloyd Herb. *35621*.

Cordyceps olivacea is apparently the same as *C. olivaceo-virescens*. The oblique perithecia effectively separate the species from *C. olivascens*.

Teng (12) has reported a collection from China on a coleopterous insect as *C. olivacea*. He describes the clavae as solitary, 4–5 cm. long, 1.5–2 mm. thick, olivaceous when fresh, umber when dry and the perithecia as immersed, ovate, 320–380 × 150–160 μ with asci 220–250 × 8 μ. The orientation of the perithecia is not described. Since in the immediately preceding discussion of *C. olivaceo-virescens* great emphasis is placed on oblique perithecia, it is probably safe to assume that the perithecia in the specimens reported as *C. olivacea* are arranged at right angles to the surface of the clava. It therefore is not *C. olivacea.* It differs from *C. olivascens* in the much smaller asci. It may be *C. joaquiensis.* The latter is illustrated as very cespitose but is described as cespitose or solitary. The asci are described as much narrower, 4 μ.

CORDYCEPS CURCULIONUM (TUL.) SACC.

Cordyceps curculionum was described by Robin (9) under the name *Sphaeria (Cordyceps) entomorhiza* Dickson. Tulasne (13) pointed out that it was not that species and proposed the name *Torrubia curculionum* for it. Robin described and illustrated a *Cordyceps* having long, slender, simple or furcate, bicolored clavae with ovoid heads. The heads and upper part of the stipes are light yellowish and the lower portions of the stipes a brownish black. According to Saccardo (10) the heads of the clavae are clavate to ovoid, 2–2.5 × 1.5–2 mm., and flavo-griseus and the stipes 18 mm. long, 0.25–0.5 mm. thick, whitish above and brownish below. The asci are described as cylindric, 300–350 × 4–6 μ, and the ascospores as filiform breaking into elongated ovoid segments, 8–9 × 1.5 μ.

Spegazzini (11) described a similar fungus from Brazil under the name *Cordyceps Puiggarii.*[3] The stipes are described as 3–6 cm. long, 0.5 mm. thick, fusco-ater below and carneo-luteus above. The heads are elliptic-sublimoniform, 2–3 × 1.5–1.75 mm., very smooth and carneo-luteus. The perithecia are 800 × 100 μ, entirely embedded and arranged horizontally. The asci are cylindric, 250 × 6–8 μ, and the filiform ascospores break into segments 5–10 × 1 μ. Petch (8) has stated that this is *C. curculionum.*

In a specimen from British Honduras reported by the writer (5) as *C. curculionum* the perithecia have been found to be oblique. They are narrowly conoid, 780–1020 × 264–300 μ, entirely embedded, overlapping upward with their longitudinal axes oblique to the surface of the head. This arrangement is illustrated by Robin (9) in the original description of *C. curculionum*. If the Brazilian collection has horizontal perithecia as described by Spegazzini it would belong in another species without a valid name. However the measurements given by Spegazzini for the perithecia in relation to those for the head would make a horizontal arrangement appear doubtful and the identity of the collections of Puiggari questionable.

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[3] As pointed out by Petch (8) the name *C. Puiggarii* was previously used by Spegazzini, for another species (probably *C. sphecocephala*).

CORDYCEPS SALEBROSA

In 1941 a specimen of a *Cordyceps* with bicolored clavae on a beetle was received from G. W. Martin. This differs from the preceding in several important aspects and is described as a new species as follows.

Cordyceps salebrosa sp. nov. (FIG. 2). Clavis 3.5–4.0 cm. longis, capitulis oblato-globosis, 1.0 mm. crassis, 1.5 mm. latis, pallide cremeis (lectis rubris), super salebrosis, stipitibus filiformibus, 0.2–0.3 mm. crassis, deorsum fusco-atris, sursum concoloribus capitulis; peritheciis immersis, anguste conoideis, 840–1200 × 240–300 μ; ascis anguste cylindraceis, 600–660 × 6 μ; ascosporis filiformibus, in articulis, 6–10 × 1–1.5 μ, frangentibus.

Ex coleoptero. Specimen typicum, Barro Colorado Island, Panama Canal Zone, 24 Julii, 1935, L. Hare in Herb. Univ. Mich. conservatum.

Clavae 3.5–4.0 cm. long, emerging between the thorax and abdomen of a beetle, capitate, the heads oblate-globoid, 1 mm. thick, 1.5 mm. wide, light cream color after being preserved in alcohol, reported as red when fresh, very irregular on the upper surface, the stipes filiform, 0.2–0.3 mm. thick, brownish-black below, concolorous with the heads in the upper 3–4 mm.; perithecia narrowly conoid, 840–1200 × 240–300 μ, vertical, completely imbedded in the head; asci narrowly cylindric, 600–660 × 6 μ; ascospores filiform, breaking into segments 6–10 × 1–1.5 μ.

From imago of a beetle (Elateridae), Barro Colorado Island, Panama Canal Zone, July 24, 1935, L. Hare (type).

The specimen was preserved in alcohol and the heads and short portions of the stipes immediately below the heads are now a light cream color and the remainders of the stipes are brownish black. According to the collector the upper portions of the clavae were red when fresh. The beetle was apparently attached to the substratum by a dense mat of brownish mycelium.

The flattened heads resemble those of *Cordyceps dipterigena* Berk. & Br. on flies. The upper surfaces of the heads are more irregular. Apparently this is due to the upper layer of the stroma conforming to the upper portions of the perithecia. The bicolored clavae and the flattened irregular heads taken together distinguish this species from others previously recorded on beetles.

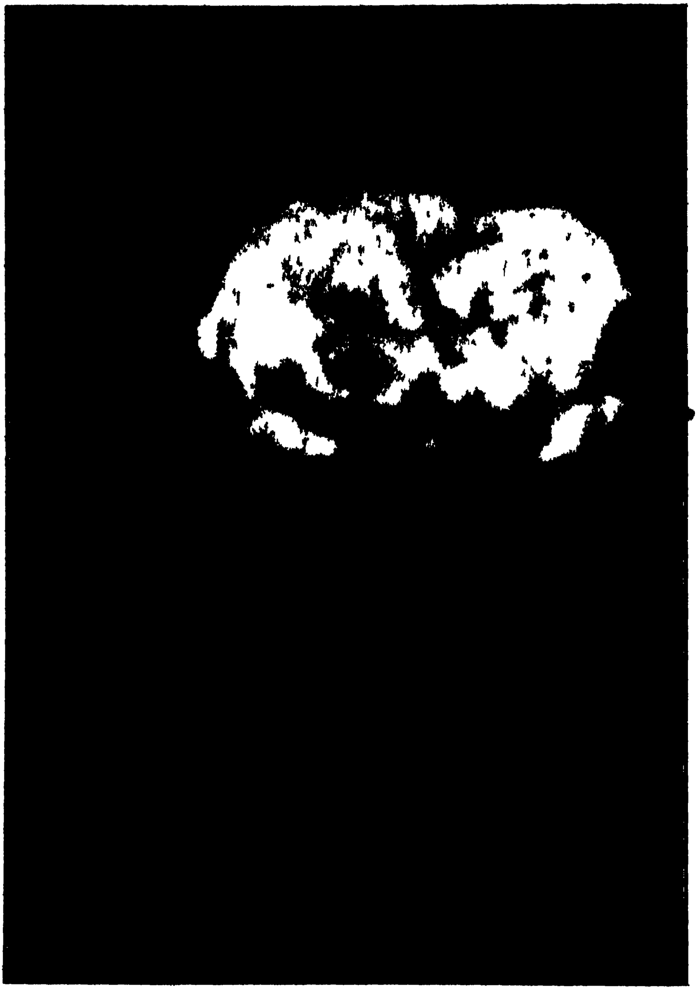

Fig. 2. Head of the clava of *Cordyceps salebrosa* showing flattened shape and irregular surface. × 40.

Cordyceps venezuelensis sp nov (FIG 3, A & B)

Clavis numerosis, gracilibus, contortis, simplicibus vel irregulariter furcatis, 2 cm longis 0 8 mm crassis, pallide luteo-brunneis, perithecus superficialibus liberis, dispersis et irregulariter confertis ovoideis, 288–324 × 182–204 μ, ascis fusoideo cylindraceis, 138–204 × 4–5 μ, ascosporis filiformibus, 108–130 × 1 5 μ, multiseptatis

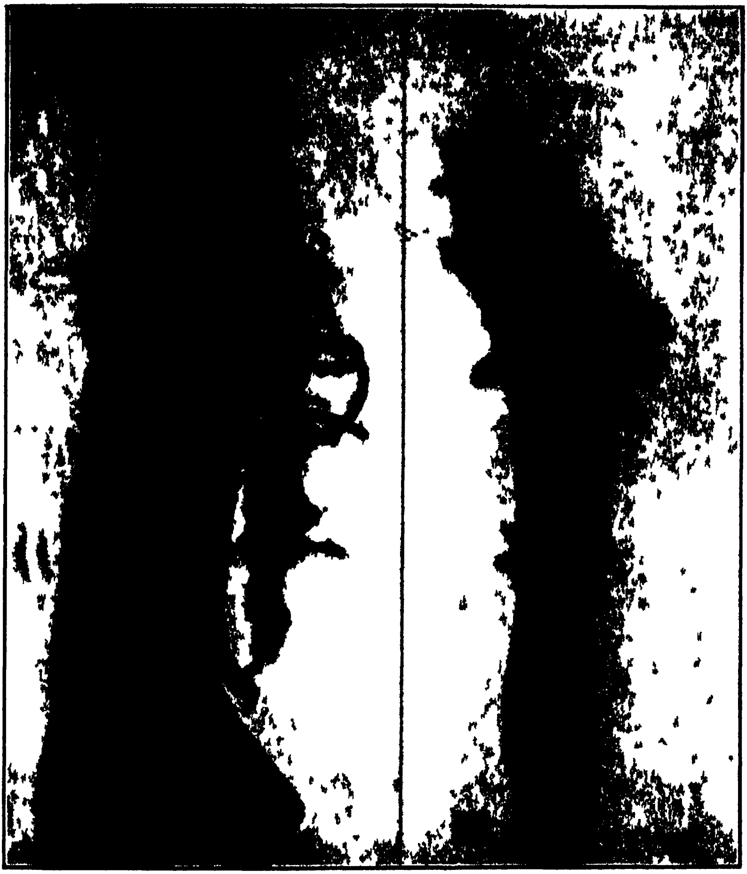

FIG 3 A Lepidopterous larva showing clavae of *Cordyceps venezuelensis* arising from various portions of the body Approximately × 2 5

B Upper portion of a clava showing the superficial, irregularly distributed perithecia × 15

Ex larva lepidopteri Specimen typicum, Yaracuy, Venezuela, 6 Jan, 1938, Carlos E Chardon (*2557*), in Herb Dept Plant Path, Cornell Univ conservatum

Clavae numerous from all parts of the larva, very irregular, simple or irregularly furcate above, up to 2 cm. long, 0.8 mm. thick, twisted, light yellowish brown; perithecia ovoid, superficial, free, scattered and irregularly crowded in groups, with portions of the clavae without perithecia, 288–324 × 182–204 μ; asci fusoid-cylindric, 138–204 × 4–5 μ; ascospores filiform, 108–130 × 1.5 μ, not breaking into fragments.

On lepidopterous larva in dense forest, Central Lucinda, Yaracuy, Carababo, Venezuela, Jan. 6, 1938, Carlos E. Chardon (*2557*).

This collection was received from H. H. Whetzel who was engaged with Carlos E. Chardon in a study of the fungi of Venezuela. The species varies considerably in its development. The clavae which arise from all parts of the insect (FIG. 3A) are simple or produce short irregular branches near the apex. The superficial perithecia are very unevenly distributed (FIG. 3B). This species appears to be close to *Cordyceps flavo-brunnescens* P. Henn. It differs in having more slender clavae and broader asci and ascospores.

CORDYCEPS MYRMECOPHILA CES.

Cordyceps myrmecophila has previously (6) been reported from the state of Washington. Two additional collections have been received, one from Oregon and the other from British Columbia. From these the following description has been prepared.

Clavae 8–25 (40) mm. long, capitate, the heads ovoid, 2–4 × 1–2 mm., ochraceous to ochraceous salmon (R), irregularly slightly longitudinally ridged, the stipes slender, 0.3–1.0 mm. thick, concolorous with the head or somewhat lighter, sometimes whitish below; perithecia narrowly ovoid,[4] 600–1020 × 192–300 μ, entirely embedded except for the slightly projecting ostioles, extending upward and oblique to the surface of the head; asci narrowly cylindric, 480–720 × 4–6 μ; ascospores hyaline, filiform, breaking into one-celled fragments, 8–10 × 1.5 μ.

On ants, Vancouver, British Columbia, April 16, 1941, J. F. Davidson; Bruin Run Creek, Mount Hood, Oregon, September 24, 1944, Wm. B. Gruber and A. H. Smith (*19033*).

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[4] The perithecia were previously (6) erroneously described as obovoid.

The Oregon specimens have the longest stipes, due apparently to the depth to which the infected ants were buried in the soil. This also resulted in a much lighter color for the lower portion of the stipes. When fresh the heads are almost smooth becoming slightly irregularly ridged due to the greater shrinkage of the stromata between the oblique upwardly projecting perithecia.

Mr. Davidson found the species was very prevalent on ants in one locality at Vancouver in 1941. When he revisited the locality in 1944, although less numerous, the fungus was still fairly abundant.

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THE IDENTITY OF "METARRHIZIUM GLUTINOSUM" *

W. Lawrence White and Mary H. Downing

(with 2 figures)

Shortly after the beginning of the war, members of the Division of Cotton and Other Fiber Crops and Diseases, United States Department of Agriculture, in connection with work on the preservation of cotton fabrics, obtained from stored baled cotton in Washington, D. C. (4) an isolate (*1334.2*) representing a then unknown species of fungus, and a little later (2, 4) two additional isolates, *1334.1* and *1334.3*, representing the same species, from Maryland soils. Work there, based on *1334.1* (3) and perhaps to a lesser extent (2, 4) on *1334.2* and *1334.3*, soon demonstrated the species to be highly adapted to use in laboratory work pertaining to the microbiological decomposition of cotton fabrics, and later (4) *1334.2* was made the type of a new species.

After the microbiological decomposition of military fabrics in the tropics became recognized as a serious problem and a program for the development of preventive measures got under way, these cultures were widely distributed to governmental, commercial, and university laboratories in this country and throughout the British Empire. Toward the end of the war *"Metarrhizium glutinosum,"* as the species was called in deterioration work, was used perhaps more than any other, not excluding the previously universally employed *Chaetomium globosum*, in the assessment of preservative treatments of fabrics. The species is now used in the Biological Laboratories of the Philadelphia Quartermaster Depot in research on the chemical nature of the fungus breakdown of cellulose, and is used elsewhere wherever similar work or assessment testing is being conducted. Its mineral nutrition, temperature, and pH relationship to cellulolytic activity were investigated recently in a Quartermaster sponsored project at the Pennsylvania State College but the results are not as yet published.

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* Presented at the Meeting of the American Association for the Advancement of Science, Boston, December, 1946.

Finally the species was introduced to the field of antibiotics when British workers (1) extracted from filtrates of a culture obtained from the U.S.D.A. an antifungal substance which they named glutinosin. Extracted along with the glutinosin but remaining in the mother liquors after crystallization of the glutinosin was another biologically active material causing a dermatitis of humans similar to that caused by poison ivy, thus necessitating the wearing of barrier creams in working with culture extracts of the mold.

Though the culture first introduced to the literature was *1334.1*, it appears that *1334.2* was the one that was most generally and widely distributed, and on which most, if not all, later work in the various laboratories was based.

In view of the foregoing interest and activity, this note is presented for the purpose of calling attention to the need for further inquiry into the true identity and relationship of what is now masquerading under the name *Metarrhizium glutinosum*. The name is unfortunate from both the scientific and economic points of view, viz.: (1) it places the species as next of kin to an insect-inhabiting form to which presumably it bears no close relationship in biological activity, thus misleading workers interested in cellulolytic activity or antibiotics or other fields of endeavor, who may for obvious reasons wish to survey related forms; (2) it breaks the continuity of the literature, submerges earlier records, and stands in the way of co-ordination of effort among the various interested laboratories and individuals; and (3) the addition of new names to the literature for organisms with long prior records, and which ought to be identified, is a practice which must be more vigorously condemned in the future than it has been in the past.

What, then, is "*Metarrhizium glutinosum*" and where are to be found other species which are phylogenetically related and which might exhibit more or less similar cellulolytic, antibiotic, and other biological activity?

THE GENUS MYROTHECIUM

There is a genus *Myrothecium* which has been known—in a sketchy way, to be sure—for some 150 years. During this period it has accumulated about a dozen species. All are very inadequately known, but the best known and evidently the most common are what have been correctly termed by Preston (5), working in England, the three basic species: *M. inundatum* Tode ex Fr., *M. roridum* Tode ex Fr. and *M. verrucaria* (Alb. & Schw.) Ditm. ex Fr.

Dr. John Stevenson has kindly loaned the writers the *Myrothecium* folder from the general collection of the Pathology and Mycology Collections of the United States Department of Agriculture. It contains thirty-five packets, representing, according to the labeling, six species, of which twelve are said to be *M. roridum* and eleven *M. verrucaria.* Examination of the lot indicates the existence of considerable confusion in the nomenclature but that the collections do actually represent a group of at least six reasonably closely allied species. A re-sorting of these places fifteen specimens under *M. roridum* and four in *M. verrucaria.* A more complete treatment will have to await the appearance of a monograph of the genus, which is badly needed.

The attention of Preston (5) was drawn to the systematics of the genus in an attempt to identify a form actively pathogenic to the cultivated violet, *Viola tricolor,* in England. This he established as *M. roridum,* which was isolated also from tomato and snapdragon plants in England and from several species of plants in Sierra Leone, and which showed some indication of pathogenicity to several species. He recorded *M. verrucaria* from Southern Rhodesia, Cyprus, and the Sudan. The Cyprus culture was from living potato haulms and was believed to have been pathogenic. An isolate (made in 1943) from an old canvas shoe (possibly American) was said to be the first record of the species in the British Isles. It may be noted at this point that in North America *M. roridum* was reported (6) to have been the cause of a crown canker of snapdragons in a commercial greenhouse in Texas in 1933–34, killing 90 per cent of the plants, and that more recently it has received attention as a pathogen of greenhouse snapdragons in Colorado (8).

Preston appears to have established the identity of the "three basic species," previously mentioned, about as adequately as will ever be possible. The one weakness in his treatment of *M. verrucaria* is that the type, if still in existence, was not available for his examination. Nevertheless, since his coverage of historical material and literature is good, his work is acceptable, and the species may be considered as adequately established in accordance with his treatment.

A comparison of the USDA *1334.2* culture with Preston's description and illustrations of *Myrothecium verrucaria* disclosed no detectable differences. The conclusion that the American cultures, under the name *Metarrhizium glutinosum*, were conspecific with the British cultures of *Myrothecium verrucaria* was confirmed by further comparisons as indicated on the following pages. Therefore, *Metarrhizium glutinosum* Pope should be referred to synonymy under *Myrothecium verrucaria* (Alb. & Schw.) Ditm. ex Fr.

MORPHOLOGICAL COMPARISON OF BRITISH AND AMERICAN CULTURES

One of the cultures cited by Preston (5, p. 168) was requested and obtained by the writers from Mr. George Smith of the London School of Hygiene and Tropical Medicine, who had originally furnished it to Preston after it had been isolated from a canvas shoe in England. The culture when received at Philadelphia was given the number PQMD *185*. A detailed comparison of its microscopic characters with those of USDA *1334.2* revealed no differences whatsoever. When the two numbers were grown in parallel series on plates of potato dextrose agar (FIG. 1A, B) there likewise were no differences. A culture of *Myrothecium roridum* (PQMD *188*), furnished by Dr. Stevenson after it had been isolated from tomato fruits intercepted at the Mexican-United States border by quarantine inspectors of the U.S.D.A., was grown in the same series (FIG. 1C). Its growth pattern, as indicated in the photograph, was only slightly different. This difference is of no significance in the separation of the two species since both have often been observed to sporulate in definite and sharply delimited concentric zones. The two species are very closely related as evidenced not only by their morphology but also by their occurrence, distribution, and biological activity. The best, and perhaps the only, distinguishing character is the spores, which in *M. verrucaria* are more or less ovoid with a peculiar and characteristic outline,

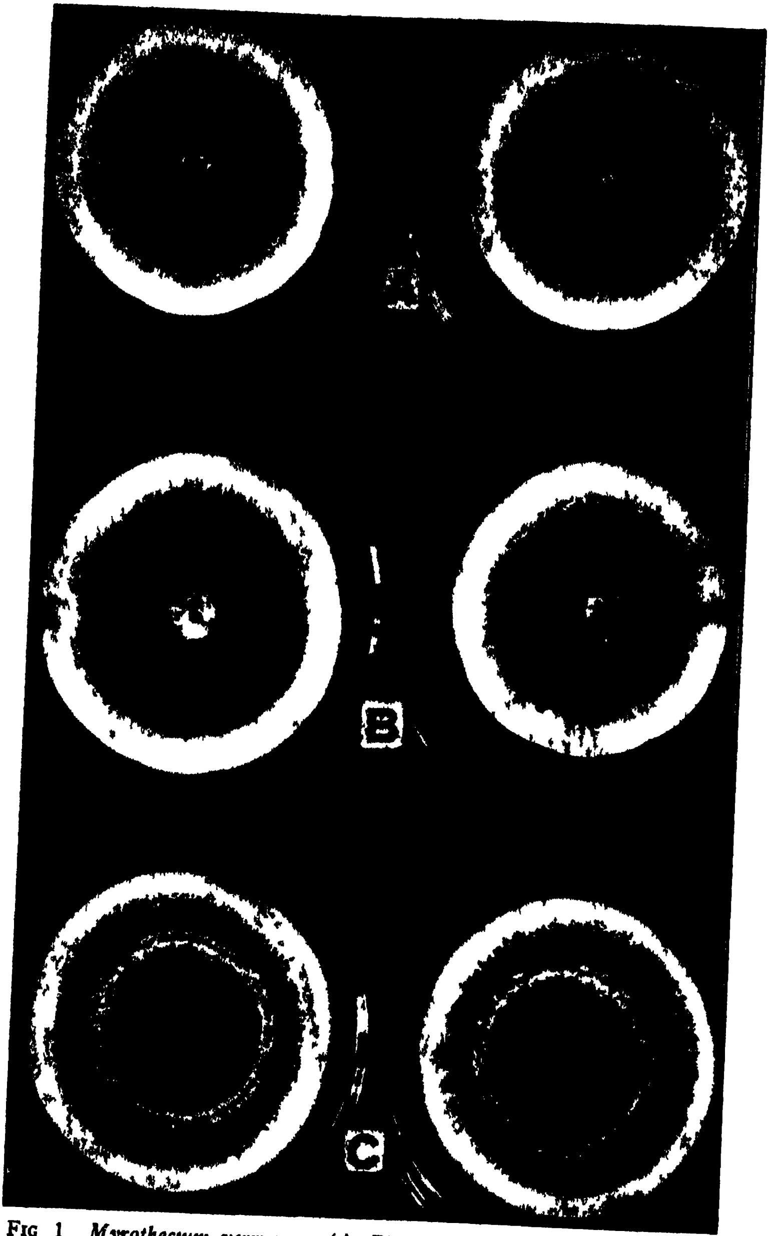

FIG 1 *Myrothecium verrucaria* (A, B) and *M roridum* (C) on potato dextrose agar

whereas in *M. roridum* they are narrow and cylindric. The microscopic characters of *M. verrucaria* were adequately described and illustrated by both Preston and Pope, and of *M. roridum* by Preston.

More recently the remaining USDA cultures of "*Metarrhizium glutinosum*," *1334.1* and *1334.3*, were supplied by Dr. Paul Marsh and the additional cultures cited by Preston were obtained from him. They exhibit no noteworthy variation and all represent the same species. Preston's cultures of *Myrothecium roridum* were also made available.

CELLULOLYTIC ACTIVITY IN PURE CULTURE ASSAY

The cellulolytic activity of Cultures PQMD *185* and USDA *1334.2* representing *Myrothecium verrucaria* and PQMD *188* representing *Myrothecium roridum* was compared as follows:

Strips of 3.3 oz., relatively size-free, bleached cotton sheeting were raveled to a width of exactly 1 inch, cut to six-inch lengths and placed 1 each in 150 × 25 mm. test tubes each containing 25 ml. Greathouse Formula A mineral salts solution (3) with lower half of strip submerged, and autoclaved 20 min. at 15 lbs. pressure. Inoculum was prepared as follows: Each of the three organisms was grown on 2 per cent potato dextrose agar slants for 17 days. Formula A solution was placed in the tubes, the spores gently dislodged by agitation with the tip of a pipette, and the suspensions emptied into flasks containing glass beads and shaken. The spore counts were adjusted to approximately 22,000,000 per ml. for each of the three cultures to be tested. Two ml. of the resulting suspension was pipetted evenly over the exposed portion of each strip. Incubation was in a room set at approximately 85° F. and 80 per cent relative humidity. At harvest the strips were removed from the tubes, washed in 95 per cent alcohol, rinsed in tap water, dried in the laboratory atmosphere, then conditioned 24 hours in an atmosphere containing 65 per cent relative humidity, temperature 75° F., and broken on the motor driven Scott tensile strength tester with a three inch space between the jaws. Each figure in the following table represents pounds breaking strength retained, based on an average of ten replicates. The decline in

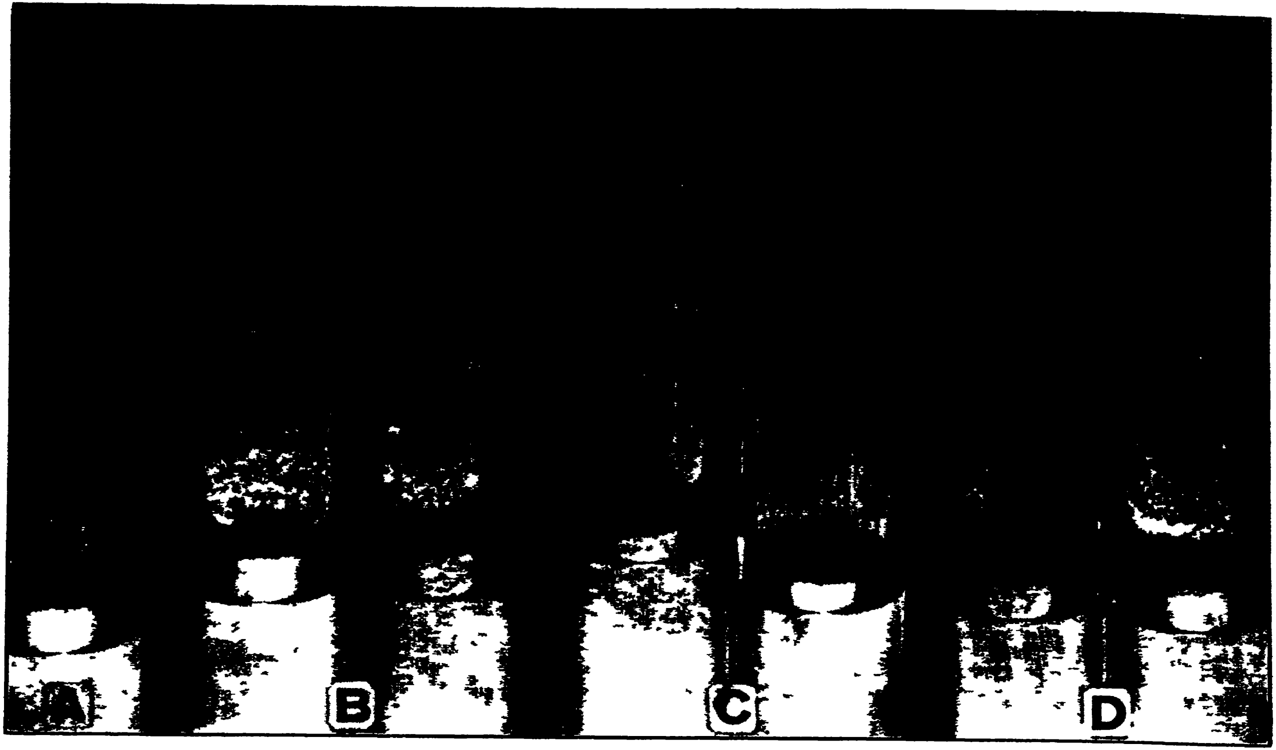

FIG 2

TABLE I

CELLULOLYTIC ACTIVITY OF MYROTHECIUM VERRUCARIA AND M. RORIDUM

Organism	Lbs. tensile strength retained		
	40 hours	64 hours	90 hours
PQMD *185* *M. verrucaria*	28.0	11.4	3.0
PQMD *188* *M. roridum*	40.7	30.5	14.8
USDA *1334.2* *M. verrucaria*	28.9	13.5	3.1
Uninoculated control	40.6	40.2	41.2

tensile strength of the cloth is taken as a measure of the cellulolytic activity of the organisms.

It will be noted from the table that under the conditions of the test the capacity of the two strains of *M. verrucaria* to break down cellulose was approximately equal whereas that of the single strain of *M. roridum* was somewhat weaker. The appearance of the three cultures on the fabric test strips after ninety hours incubation is shown (FIG. 2). Here again little or no difference is noted between the two strains of *M. verrucaria* (FIG. 2B, D). Mycelial development and sporulation is apparent over all of the exposed portions of the strips but is particularly heavy at and just above the surface of the liquid. In the case of *M. roridum* (FIG. 2C) visual growth was comparatively light and confined mostly to a rather scanty mycelial development on and just above the surface of the liquid, with little or no sporulation. In both strains of *M. verrucaria,* the cloth became intensely yellow just above the surface of the liquid and more faintly so progressively further up. In *M. roridum* a similar pigmentation was present but much less intense. As is typical of fungi tested by this method, cellulolytic action is greatest immediately above the surface of the liquid.

After the remaining cultures cited by Preston under *M. verrucaria* and *M. roridum* were received, these were also subjected to cellulolytic assay. The latter set of tests, although much less exact than the first, was sufficient to indicate that strong cellulolytic action in pure culture is a characteristic common to both species. Of approximately one hundred species of fungi surveyed in this laboratory during the past two years, none has been found to exhibit stronger action. A few approach it, but the vast majority act more slowly, and of course many are wholly non-cellulolytic.

OCCURRENCE ON FABRICS AND PLANT MATERIALS IN THE FIELD

A preliminary examination of herbarium material from the U. S. Department of Agriculture, and to a lesser extent from other sources, together with a review of literature records, a few of which were cited on previous pages, indicates that both *M. verrucaria* and *M. roridum* are fairly common and of widespread occurrence in both North America and Europe and in the tropics. *M. verrucaria* appears to be the less common of the two species. Most of the specimens from the U.S.D.A. are on plant debris. However, some furnish additional evidence that both, but especially *M. roridum,* are capable of invading the living tissues of a wide range of herbaceous economic plants. One, for example, taken in Virginia in 1937 shows numerous sporodochia of *M. verrucaria* on a large necrotic area on a tomato fruit. The sporodochia of *M. roridum* are abundant in concentric rings of leaf spots of *Hibiscus* sp. from Honduras, and of *Citrus maxima* from Puerto Rico, presenting unmistakable evidence that *M. roridum* is the causal agent of the disease.

Among several thousand cultures at hand, made from deteriorated cotton fabrics and related military and industrial materials, mostly from tropical exposures, these two species appear only a few times. In a few instances *M. roridum* has been found sporulating on the fabric, but in no case has *M. verrucaria* been seen on the several hundred molded samples which have been thoroughly examined. As pointed out recently (7) by the senior author, *M. verrucaria,* despite its strong cellulolytic activity in pure culture laboratory tests and its special adaptability to laboratory experimental work, appears to be of little significance as a destroyer of cotton fabrics in the field.

UNITED STATES ARMY QUARTERMASTER CORPS BIOLOGICAL LABORATORIES,
2800 SOUTH 20TH STREET,
PHILADELPHIA, PENNSYLVANIA

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EXPLANATION OF FIGURES

FIG. 1. Species of *Myrothecium* after two weeks on potato dextrose agar (20 g. dextrose per liter), 35 cc. medium in each dish, under room conditions.—A, PQMD *185, M. verrucaria,* isolated from an old canvas shoe in England and recorded by Preston as *M. verrucaria;*—B, USDA *1334.2, M. verrucaria,* isolated from stored baled cotton in Washington, D. C. and made by Pope the type of a new species, *Metarrhizium glutinosum;*—C, PQMD *188, M. roridum,* isolated from tomatoes which had been intercepted at the Mexican border by quarantine inspectors of the U. S. Dept. of Agriculture. Magnification approx. 3/8. (By Photographic Dept., Philadelphia Quartermaster Depot.)

FIG. 2. Species of *Myrothecium* after 90 hours incubation on bleached cotton sheeting in the presence of Greathouse Formula A mineral salts solution in a room set at 85° F. and 80 per cent relative humidity—A, Control; —B, PQMD *185, M. verrucaria;*—C, PQMD *188, M. roridum;*—D, USDA *1334.2, M. verrucaria.* Magnification × 9/10. (By Photographic Dept., Philadelphia Quartermaster Depot.)

A NEW GYMNOCARPOUS HETEROBASIDIOMYCETE WITH GASTEROMYCETOUS BASIDIA

DONALD P. ROGERS

(WITH 1 FIGURE)

The hitherto unknown fungus here described grows as a parasite on the hymenium of a minute, inoperculate discomycete superficially resembling the genus *Mollisia.* The host ascocarp, scarcely exceeding half a millimeter in diameter, is barely discernible; the parasite, occurring on only occasional apothecia, is nearly imperceptible to the naked eye, can be detected under the hand-lens only because of its whitish color, and even under the highest magnification of the dissecting binocular appears as no more than a white nap, somewhat convex in profile, covering the gray hymenium of the host. The first collections were the accidental result of bringing the ascomycete into the laboratory, and the few subsequent collections were possible only through persistent search for the host.. The fungus must be sought as an alien fuzz on a small discomycete (*Hyaloscypha atomaria*), and is accordingly named *Xenolachne* (from Ξένος, a stranger, and Λάχνη, down or fuzz).

The fructification consists of a layer of ovoid or ellipsoid basidia supported on a scanty subiculum of clamp-bearing mycelium, the whole resembling, except for the absence of gelatinous texture, an extremely minute *Sebacina.* The young basidia (FIG. 1, *A–E*) are like those of most species of *Sebacina* except that they develop only one longitudinal septum; and even in this they resemble those of at least one species (unpublished) of *Sebacina*, or those of *Tremella simplex* Jackson & Martin (Martin **1940**: 687) or of some gatherings of *Phlogiotis Helvelloides* (Martin **1936**: 628), or some of the basidia of *Hyaloria Pilacre* (Möller **1895**: 139). Each of the two segments puts out from its apex a tubular or blunt-conic epibasidium (FIG. 1, *F, G*) in no essential different from that of any of the Tremellaceae which possess epibasidia, and the epibasidium in turn gives rise to a sterigma (FIG. 1, *H–M*). It is the sterigma that is the characteristic and significant organ of *Xenolachne:* instead of being subulate and relatively short, as in the Tremellaceae, it is fantastically elongated (to 35 μ), straight, quite uniform in diameter, and unprecedentedly slender. The sterigmata form the hazy, tenuous fuzz observed under the binocular; or rather, since they are too narrow to present a visible surface at such magnification, it is the light reflected from them, as light is reflected from invisible dust-particles in a sunbeam. None of the sterigmata studied in KOH-phloxine preparations under the oil-immersion lens exceeded 0.2 μ in diameter, and many appeared to be less; in lactophenol, which occasionally is useful to bring out the wall in fungi where KOH seems to show only the protoplast or lumen, the results were no different. The observational error inherent in the estimation of fractions of a division of the ocular scale and in the resolving power of the microscope would make more precise measurement meaningless. The sterigma swells at its tip to form an oblong basidiospore, whose axis is a projection of the axis of the sterigma, and which is without an apiculus (FIG. 1, *L, M*). The spore is abstricted by the breaking, below a septum, of the sterigma, a part of which remains attached to the spore as a false apiculus (FIG. 1, *N–P*); it germinates either by the formation of a sterigma and secondary spore (FIG. 1, *Q–S*) or by mycelium (FIG. 1, *T*), which, as is not surprising in a species with two-spored basidia, has clamp-connections at its earliest septa. At least the majority of the secondary spores are like those of other heterobasidiomycetes in being borne obliquely.

The sterigma, and its relation to the basidiospore, are of a type characteristically gasteromycetous. This is not to say that there is a single basidial type characteristic of the gasteromycetes. But as a correlative of angiocarpy the gasteromycetes have all lost the ability to discharge the spores from the basidia, and with this the structures which in the hymenomycetes make such discharge possible (Rogers **1934**: 168, 179–80). Basidial degeneration has taken various directions in the several groups of gasteromycetes; and one such direction, well shown in a number of the Lycoperdaceae (*e.g.*, many species of *Lycoperdon*), is the development of very long, slender, fragile sterigmata bearing their spores symmetrically and setting them free by fracture at or below the point of attachment. This is exactly what occurs in *Xenolachne.*

In this sense, then, and to this degree, *Xenolachne* is gasteromycetous: its basidia show a type of degeneration and a manner of spore-production characteristic of the gasteromycetes. To employ a useful conception and term, *Xenolachne,* like the gasteromycetes, possesses apobasidia.[1] In other respects it shows no resemblance nor evidence of relationship to them. In the gasteromycetes basidial degeneration is the concomitant, and quite probably the result, of angiocarpy; the fructification of *Xenolachne* not only has no peridium, but even lacks the gelatinous hymenial matrix in which in most Tremellales the basidia are more or less completely immersed. As a group, and especially among their least modified forms (*Endoptychum, Montagnea*), the gasteromycetes are conspicuously xeromorphic, and their origin is probably a response to the limitations of an arid habitat; *Xenolachne,* like other delicate heterobasidiomycetes, develops its fructifications under conditions of continuous high humidity—on the lower surface of water-soaked logs, in mesophytic forests, during wet weather—and is, in fact, more readily damaged by exposure to the air of the laboratory than are most related fungi. The ecological significance of its apobasidia is entirely obscure. It is to be supposed that the sterigmata, instead of discharging their spores, retain them until separation is effected by some mechanical disturbance. There is some temptation to guess at distribution by small arthropods, or at a mode of dissemination by which the basidiospores of the parasite are carried along with the ascospores of the host when the latter are discharged. But no evidence exists of arthropod agency, and the apothecia of the host appear to be too heavily infested to permit normal formation of ascospores, let alone their discharge through the *Xenolachne* fructification. No more is known than that a completely gymnocarpous form has here reverted to an essentially conidial manner of dissemination of basidiospores.

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[1] Vuillemin (**1912**: 349) introduced the term *apobasidium* for "des basides secondairement déformées," but mistakenly, as it now appears, applied it to *protobasidia,* a rough equivalent of the better conceived category of *heterobasidia.* In that sense it was of course quite superfluous. Later E. J. Gilbert (**1928**: 225–6) published the group Apobasidiomycetes, explicitly limited to those Autobasidiomycetes in which "les spores sont terminales et symétriques à l'extrêmité et dans le prolongement axial des stérigmates." As a formal designation of a taxonomic group, Apobasidiomycetes is exactly synonymous with Gasteromycetes, and therefore both superfluous and invalid. In addition, Gilbert used the term *apobasidium* for basidia forming sterigmata and spores in the relation just described. It is this sense of the term which seems to have been accepted (Snell **1936**: 12; Ainsworth & Bisby **1945**: 39). It would be difficult to coin a name more suitable for a basidium deprived of one of its primary functions, that of spore-discharge; the appropriateness is not diminished by Gilbert's denial of phyietic implications. It should, however, be noted that while Gilbert clearly intended the term to refer to all basidia of gasteromycetes, his description excludes those forms in which the sterigma has been not modified but lost—that is, those, like *Melanogaster,* with sessile spores.

It is now proposed that *apobasidium* be used with the phyletic connotation stated by Vuillemin, for degenerate basidial types; that it be applied not only to such basidia as those described by Gilbert but also (as he apparently intended) to those in which the sterigmata have disappeared; that it be not limited to the subclass Homobasidiomycetes (nor to the Autobasidiomycetes), but used also for certain basidia among the Heterobasidiomycetes; and that it be employed not in antithesis to *heterobasidium* and *homobasidium* but as a complementary term. Accordingly *Xenolachne* would possess heterobasidia which are also apobasidia, and *Lycoperdon* homobasidia which are also apobasidia. Such an emendation of the sense of the term seems permissible, and by it *apobasidium* is referred to that morphological entity which stands in need of a name. A definition is suggested: **Apobasidium**—a basidium whose basidiospores are not apiculate nor borne obliquely on the sterigmata nor forcibly discharged. EXAMPLES—gasteromycetes, Sirobasidiaceae, Hyaloriaceae, Phleogenaceae, most (if not all) Ustilaginales. There is some additional discussion by the writer (Rogers **1934**: 166–8) of the three levels of basidial evolution (though the apobasidium is not so named).

Xenolachne is unique also in the presence of both indubitable epibasidia and grotesquely elongated sterigmata. In heterobasidiomycetes with normal—that is, subulate—sterigmata the sterigma, though distinct enough, is not always conspicuous as a separate entity. In this fungus neither the *Sebacina*-like epibasidium nor the *Lycoperdon*-like sterigma can be overlooked; and to treat them as manifestations of a single structural entity is as little satisfactory as to do so for, say, the carpogonial base and the trichogyne of one of the Florideae. Here, as perhaps nowhere else, the distinctness of the two organs is obvious.

The ovate, longitudinally septate basidia of *Xenolachne* are such as to place it in that phyletic series of the Basidiomycetes characterized by hypobasidial meiosis (Rogers 1934: 165), and in that division of the Tremellales which includes the families Tremellaceae, Sirobasidiaceae, and Hyaloriaceae (Martin **1941**: 23; **1944**: 11; in Ainsworth & Bisby **1945**: 406). Of these families it is clearly foreign to the Sirobasidiaceae, in which the basidia are catenate and the spores sessile. Since *Xenolachne* is gymnocarpous, it might be assigned to the Tremellaceae, and more particularly, because of its resupinate fructification, to a position near *Sebacina*. By existing keys and descriptions it would be excluded from the Hyaloriaceae, whose single genus is ostensibly angiocarpous and unquestionably stipitate. But the presence or absence of a stipe has not usually been considered to be of sufficient importance to constitute by itself the basis for the assignment of fungi to different families; and since abundant cases are known where fungi differing on this point agree on all others of any importance, it is apparent that here taxonomic habit is supported by what is known of comparative morphology or can be inferred concerning phyletic relationship. The difference between gymnocarpous and angiocarpous development is of considerably greater weight. In *Hyaloria*, however, the basidia are merely considerably overtopped by the paraphyses and immersed in a layer of gelatinous material to which the paraphyses give rise (Möller **1895**: 137–40, 173; pl. 1, *fig*. 3; pl. 5, *fig*. 37; Martin **1937**: 620–4; *fig*. 10–27); there is nothing approaching a peridium and, except that the spores are not formed at the surface, nothing in the organization of the fruiting layer to distinguish it from those species of *Sebacina* and *Tremella* which have long and abundant paraphyses (cf. the figures of *Sebacina epigaea* given by McGuire, **1941**: pl. 1, *fig*. 2, 4). This published evidence is abundantly supported by study of specimens of the fungi cited. The great taxonomic significance of angiocarpous development, at least among basidiomycetes, lies not in angiocarpy itself, but in the profound changes in structure and behavior of fruiting organs that accompany, and have apparently been induced by, angiocarpy. The significant character of *Hyaloria* is not that the hymenium is enclosed (it is not), nor even that the basidia are embedded in gelatinized paraphyses (those of *S. epigaea* and of other Tremellaceae are more deeply embedded), but that its spores are terminal and symmetrical on the sterigmata and are freed as are conidia or the spores of gasteromycetes. In this respect *Hyaloria* does not differ from *Xenolachne.* The one is stipitate and the other resupinate; the one lacks epibasidia and the other has retained them; the one develops its spores among gelatinized paraphyses and the other in the air. But because both have tremelloid hypobasidia (and presumably an origin from the Tremellaceae) and both have symmetrical spores separated by fracture from capillary sterigmata, the two genera appear to be closely related (though not necessarily in series), and are accordingly assigned to the one family. Möller's description of the Hyaloriaceae reads: "Der angiokarpe Fruchtkörpertypus . . . er fand sich abermals vor, ausgestattet mit Basidien der Tremella-Form." As already noted, neither Möller's account nor his figures support the assertion that *Hyaloria* is angiocarpous; that assertion seems to be one of Möller's attempts to display his newly discovered genera as the fulfilment of Brefeld's prophecies concerning the structural diversities of the basidiomycetes (Möller **1895**: 143; Martin **1934**: 144). To eliminate that error, as well as to permit the inclusion of the additional genus, that diagnosis has been emended, and the character of angiocarpy replaced by the essential one of the relation of spore to sterigma.

HYALORIACEAE Möll., Protobas. (Schimper, Bot. Mittheil. Troper **8**:) 137, 143. 1895, emend.

Hypobasidia longitudinally septate; basidiospores without apiculi, borne on filiform sterigmata, with respect to which they are symmetrical and coaxial.

Genera: *Hyaloria* (type), *Xenolachne.*

Xenolachne gen. nov. Hyaloriacearum

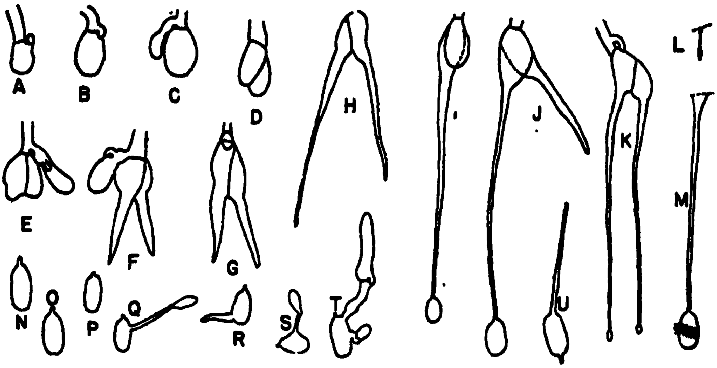
Fructificatio resupinata; hypobasidia longitudinaliter septata, eorum segmentis tot epibasidia tubuliformia gerentibus, sterigmatibus filiformibus, longitudine variis; sporae recte in sterigmatibus porrectae, sine apiculo genuino, sterigmatis apicem sicut apiculum retinentes, per repetitionem germinantes.

Basidiocarp resupinate; hypobasidia longitudinally septate, each segment bearing a tubular epibasidium continued in a sterigma of variable length; basidiospore without a proper apiculus, borne symmetrically upon its sterigma, and after abstriction retaining the terminal portion of the sterigma as a false apiculus, germinating by repetition.

Type: *X. flagellifera.*

Xenolachne flagellifera sp. nov.

Basidiocarpium album, minutissime pilosum; hyphae nodoso-septatae, 2 μ diam.; hypobasidia elongato-ovata vel ellipsoidea, 7.5–10 × 5–6 μ, longitudinaliter uniseptata, epibasidia duo gerentia 2–3 μ diam., 10 μ long., in sterigmata filiformia ad 35 μ long., 0.2 μ crass.; producta; sporae oblongo-cylindraceae, apice sterigmatis ornatae, 5.5–8 × 2.5–3.5 μ, per repetitionem, vel in mycelium zygodesmatibus ornatum, germinantes.



EXPLANATION OF FIGURE

(All drawings made with camera lucida, and reproduced at approximately 1000 ×.)

FIG. 1. *Xenolachne flagellifera*. A–D, young basidia; E–G, development of epibasidia; H–K, basidia with sterigmata and developing spores; L, tip of sterigma with very young spore (Note. in this figure alone the relative diameter of the sterigma is accurately represented.); M, mature spore, and septum in sterigma; N–P, abstricted spores; Q–S, germination by secondary spores (In S the germinating spore is probably itself a secondary spore.); T, germination by mycelium; U, spore germinating by a sterigma like that of the basidium.

Fructification an almost imperceptible white fuzz, under the binocular (40 ×) a delicate, glistening, snow-white pile or nap composed of very slender threads tipped by minute swellings, collapsing on drying; hyphae distinct, not gelatinized, with clamps throughout, 2 μ in diameter, a few emergent, obtuse, cystidioid, 1.5–2 μ in diameter; basidia subtended by proliferating clamps; hypobasidia elongate-ovate or -ellipsoid, 7.5–10 × 5–6 μ (or rarely subfusiform, –20 μ long), with one longitudinal septum, bearing two subcylindric or tapering epibasidia 2–3 μ in diameter and about 10 μ long, each more or less abruptly attenuated to a capillary flagelliform sterigma under 0.2 μ in diameter, up to 35 μ long; spores borne symmetrically on the sterigmata, without apiculi, oblong-cylindric, 5.5–8 × 2.5–3.5 μ, tipped by the end of the sterigma, germinating by repetition or by a clamp-bearing mycelium.

Parasitic on the hymenium of *Hyaloscypha atomaria* (Starb.) Nannf. growing on the lower side of damp logs of *Libocedrus decurrens, Pinus Strobus,* and *Pseudotsuga Taxifolia.*

SPECIMENS EXAMINED: MASSACHUSETTS: N. branch of Mill R., Springfield, IX.23.43, *A. M. & D. P. R. 1040.* OREGON: Umpqua valley E. of Reedsport, X.22.38, *A. M. & D. P. R. 487,* **type**, and *490*[2]*;* Lorane, X.22.38, *M. S. Doty,* in *D. P. R. 1039;* Alsea Rd. S. of Philomath, XII.13.38, *A. M. & D. P. R. 1038.*

For assistance with this paper I am indebted to Dr. M. S. Doty of Northwestern University, Miss Edith K. Cash of the United States Department of Agriculture, Professor G. W. Martin of the University of Iowa, and Dr. S. M. Zeller of Oregon State College. Dr. Doty supplied one of the original collections of *Xenolachne;* Miss Cash identified the ascomycetous host; Dr. Martin supplied sectioned and whole material of *Hyaloria* on which the comparison with *Xenolachne* was based; in the laboratory and in the field Dr. Zeller provided a unique introduction to the many groups of gasteromycetes with which the Northwest forests and his studies have enriched the science of mycology. Dr. Zeller and Dr. Martin have very kindly criticized the manuscript.

DEPARTMENT OF BOTANY,
UNIVERSITY OF HAWAII,
HONOLULU, TERRITORY OF HAWAII

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[2] Miss Cash identified the host from a part of this collection, in which, as in the type, it was growing on *Libocedrus.*

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WHAT IS AN ANTIBIOTIC OR AN ANTIBIOTIC SUBSTANCE? *

SELMAN A. WAKSMAN[1]

With the introduction, in 1941, of penicillin as an important chemotherapeutic agent, and with the isolation from cultures of different micro-organisms of a rapidly increasing number of new chemical substances found to possess similar antibacterial and other antimicrobial properties, it became apparent that a new name was required, which would include these and similar compounds. A request for the submittal of such a name was addressed to the writer in July, 1941, by Dr. A. Flynn, editor of Biological Abstracts. After giving this matter considerable thought, the writer concluded that the terms *antibiotic* and *antibiotic substance,* which previously had been used in a rather loose sense, might well be restricted to a specific application. It was felt that the words *antagonism* and *antagonistic action* would be best reserved for the antimicrobial activities of the living systems as a whole, whereas the newly selected words should be used to designate the action of the *chemical agents,* produced by micro-organisms and possibly other living bodies, which were responsible for these antimicrobial effects.

The use of the words "antibiosis" and "antibiotic substance" to designate antiliving processes in a very broad sense is found in the older biological literature as well as in many dictionaries. The scientific use of the word "antibiosis" dates from the concept first expressed, in 1889, by Vuillemin (5) in the following terms: "one creature destroying the life of another in order to sustain its own . . . one being in unrestricted opposition to the life of the other"; the active participant was named "antibiote." This concept was also held by Marshal Ward (13), who applied the term "antibiosis" to an association of organisms whereby one injures the other, "as exemplified by many parasites." Webster's New International Dictionary defines "antibiotic" as "tending to prevent, injure, or destroy life"; other dictionaries define the term as "injurious to or destructive to living matter."

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[1] New Jersey Agricultural Experiment Station, Rutgers University.

To indicate the limited use of the term prior to 1941 and the confusion which frequently was brought about when the word was applied to microbiological reactions, one has only to consider the classical book of Papacostas and Gaté (4), who summarized, in 1928, the knowledge on microbial associations. These authors proposed that the word "antibiosis" be defined as follows: "When in a culture where several bacterial species occur or are intentionally mixed, one organism exerts an injurious effect upon another, it is antibiosis." The word "antibiosis" was further limited to the activities of one organism upon another *in vitro* or in the test tube as opposed to "antagonism" which would apply to the action of one organism upon another *in vivo* or in the animal body. The word "antibiosis" was thus applied to mixed cultures and the word "antagonism" to mixed infections. "Reciprocal antibiosis" was differentiated from "unilateral antibiosis" and " vital antibiosis" from "functional antibiosis" Antibiotic microbes were believed to act upon other microbes indirectly, subtracting oxygen but also directly by means of a substance which they produce. To indicate the confusion thus involved, it is sufficient to quote the following: "An antibiotic microbe *in vitro* may sometimes also be an antagonistic microbe *in vivo*." The chemical thus produced is spoken of as a "toxin," and nowhere is it indicated that the same substance is involved whether the action takes place *in vitro* or *in vivo*.

Various designations were thus applied to the specific chemical substances, possessing characteristic antibacterial properties and produced by antagonistic micro-organisms (6). It is sufficient to mention some of the common terms: "bacterial toxins," "toxic substances," "staling products," "antagonistic substances," "antibiotic substances," "inhibitory substances," "bacteriolytic substances," "bacteriostatic substances," "antibacterial substances," "antimicrobial substances," "active substances," and "lethal principles."

The terms "antibiotic" and "antibiotic agent" were first used in the present sense by Waksman and his collaborators in several papers published or written in 1942 (9, 10, 11, 12). Since 1942 the terms have come into general use. The word "antibiotic" was defined (7, 8) as "inhibiting the growth or the metabolic activities of bacteria and other micro-organisms by a chemical substance of microbial origin." An "antibiotic substance" or an "antibiotic" was defined as "a chemical substance, of microbial origin, that possesses antibiotic properties."

Oxford (3), in a review of the subject of "antibiotic substances," characterized antibiotics as "soluble" and as produced from a harmless constituent of a medium. Three qualifications were attached to this definition; namely (a) an antibiotic substance shall have been isolated and tested in a pure state; (b) algae and higher plants are excluded as producers of antibiotic substances; and (c) the smallest concentration of the antibiotic substances in the medium producing a measurable effect upon the inhibited organism *in vitro* shall be of the order of 50 p.p.m. or less. Neither Oxford's definition nor the qualifications attached to it are in accord with the original definition nor with the present use of the term "antibiotic." For example, certain substances, such as tyrothricin, widely recognized as antibiotics, are definitely cell constituents and not products of a harmless constituent of the medium. If a substance is to be recognized only after it has been isolated in a pure state, what would have become of penicillin, streptomycin, and similar antibiotics, which not only were studied but were used for chemotherapeutic purposes before they were purified? Again, to delimit the concentration of an antibiotic in the medium before the antibiotic has been recognized as such would not always be justified.

Several suggestions have been made that the concept of the word "antibiotic" be enlarged, and that substances falling within the class of antibiotics be further subdivided. These subdivisions would be based upon the origin of the substance or upon its mode of action.

Chain and Florey (1), for example, suggested that all antibiotic substances be divided into two groups: (1) antibiotics that react with protoplasmic constituents and kill both bacterial and animal cells, in a manner comparable to that of "antiseptics" (in other words, those antibiotics that are toxic to the animal body); and

(2) antibiotics that react with substances having a specific significance in the bacterial cell only (since some of the latter substances are largely growth-inhibiting, they were designated as "bacteriostatics"). In his later work, however, Florey (2) apparently dropped this plan of subdivision.

Wingo (14) suggested that the term "antibiotic" be enlarged to include, in addition to microbial products, other substances that possess antibacterial properties. The group of antibiotics would thus be subdivided into "mycoantibiotics" (products of bacteria and fungi), "chemoantibiotics" (synthetic compounds), "actinoantibiotics" (radiant energy). Were such a division justified, one would have to add to this list "phytoantibiotics" (products of green algae and higher plants) and "zoöantibiotics" (lysozyme, erythrin, and other animal products). This enlarged concept is hardly desirable, for various obvious reasons.

It is quite evident that the present widespread use of the term "antibiotic" in the sense first implied by Waksman and his collaborators has evoked some philological discussion. It may be advisable, therefore, in the interest of semantics, to amplify the earlier definition as follows:

An antibiotic is a chemical substance, produced by micro-organisms, which has the capacity to inhibit the growth of and even to destroy bacteria and other micro-organisms. The action of an antibiotic against micro-organisms is selective in nature, some organisms being affected and others not at all or only to a limited degree; each antibiotic is thus characterized by a specific antimicrobial spectrum. The selective action of an antibiotic is also manifested against microbial vs. host cells. Antibiotics vary greatly in their physical and chemical properties and in their toxicity to animals. Because of these characteristics, some antibiotics have remarkable chemotherapeutic potentialities and can be used for the control of various microbial infections in man and in animals.

In accordance with this definition, plant products possessing antimicrobial properties would be eliminated from the group of antibiotics. They can either be designated as "antibiotic-like substances" or as "plant antibiotics," or perhaps even better as "phytoncides," a term proposed for this group of substances. Of course, care will have to be taken not to confuse this term with that of "phytocides," used to designate materials that act injuriously upon plants.

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SOME ASPECTS OF PENICILLIN PRODUCTION BY ASPERGILLUS NIDULANS[1]

EUGENE L. DULANEY[2]

A number of *Aspergillus* species have been shown to produce penicillin. This list of species has already been reviewed by Raper (9). In this paper he also noted that the ability to produce penicillin is more general in the genus *Aspergillus* than in the genus *Penicillium*. Penicillin producing strains, however, do appear to be commonly found within the *Aspergillus flavus* group. It seems that this ability is also commonly found within various species of the *Aspergillus nidulans* group (1).

Aside from the fact that these *Aspergilli* produce penicillin little more is known. The relatively low yields obtained from them indicate that there is little hope for them in commercial competition with *Penicillium* strains now used in production. It would be interesting, nevertheless, to learn something of penicillin production by these organisms. For this purpose a strain of *Aspergillus nidulans* was chosen.

METHODS

The strain of *Aspergillus nidulans* (Eidam) Wint. used in this research was isolated from compost. Its identification as *A. nidulans* was confirmed by K. B. Raper.

Spores from six day old honey peptone agar cultures, grown at 24° C., were used as inoculum for setting up fermentations. The spores were suspended in sterile distilled water, and one milliliter of the suspension added to each flask. The fermentation medium contained the following ingredients in grams per liter of distilled water: lactose 20.0 gr., corn steep solids (Amaizo spray dried) 20.0 gr., sodium nitrate 3.0 gr., potassium phosphate monobasic 0.5 gr., magnesium sulphate·$7H_2O$ 0.25 gr., zinc sulphate·$7H_2O$ 0.04 gr. Substitutes for the lactose and corn steep were used in certain experiments. The medium was dispensed in 100 ml. portions into 500 ml. Erlenmeyer flasks. Experiments showed that when lactose was the carbon source near-maximum production was obtained with this depth of medium. After sterilization and inoculation, the flasks were placed on a reciprocal type shaker. The speed of the shaker was 92 cycles per minute; each cycle consisted of an eight inch movement, four inches forward and four inches backward. The incubation temperature was 24° C.

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[1] Portion of a thesis submitted to the graduate school of the University of Wisconsin in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

[2] Present address: Microbiological Research Laboratories, Merck and Co., Inc., Rahway, New Jersey.

The cylinder plate method, which has been adequately described (2), was used in the assays throughout the experiments.

The changes in mycelium weight, pH, and penicillin production occurring during fermentation were followed. In addition, changes in the concentration of lactose, ammonium nitrogen, nitrate nitrogen, and organic nitrogen, were determined and correlated with the other changes. The methods for these determinations are given in the appropriate section.

EXPERIMENTAL DATA

Evidence for Penicillin Formation—Proof that an antibiotic is or is not penicillin would come with chemical purification and characterization of the substance. The active substance produced by *Aspergillus nidulans* has not been chemically characterized, but other evidence indicates that the antibiotic activity is due to penicillin.

Aspergillus nidulans and *Penicillium notatum* strain 832 were grown on the lactose corn steep medium plus salts. Both stationary and submerged fermentations were employed. When the antibiotic titers were high the mycelium was filtered off and a series of tests run on the filtrates. The tests and results are given below.

1. *Inactivation by penicillinase.* Filtrates were adjusted to pH 6.7. Penicillinase completely inactivated the filtrates after incubation for three hours at 37° C.

2. *Method of extraction.* The active substance from metabolism solution filtrates of *A. nidulans* could be extracted by a method commonly used for extraction of penicillin.

3. *Inactivation by hydroxylamine.* After incubation at 28° C. for four hours, the metabolism solution filtrates were completely inactivated by hydroxylamine.

4. *Inactivation by copper sulphate.* At a concentration which did not inhibit the test bacterium, copper sulphate inactivated the filtrates after four hours incubation at 28° C.

5. *Instability at low and high pH.* Portions of the filtrates were adjusted to pH 2.5 with 1 N HCl and other portions were adjusted to pH 10 with 1 N NaOH. After incubation at 28° C. for four hours the filtrates were readjusted to approximate neutrality and assayed. In each case the antibiotic activity had completely disappeared.

6. *Solubility.* Filtrates were adjusted to pH 2.5 with 1 N HCl and extracted with various organic solvents. The antibiotic activity from *A. nidulans* filtrates and *P. notatum* filtrates showed the same solubilities.

7. *Antibacterial activity.* Filtrates from the two organisms were tested against fourteen test bacteria. In so far as it was tested the antibacterial activity of the two molds was identical. Included among the fourteen test bacteria was a penicillin resistant *Staphylococcus aureus* which was uninhibited by either organism.

As can be seen from the above tests the reaction of the metabolism solution filtrates from the two molds was quite comparable. This comparison would indicate that the antibiotic activity of the filtrates is due to similar types of compounds. It is known that *Penicillium notatum* strain 832 produces penicillin(s) when grown under the above conditions, and it would follow that *Aspergillus nidulans* is also producing penicillin(s).

Carbon Sources—The fermentation media used for the production of penicillin by *Penicillium notatum* or *P. chrysogenum* frequently contain lactose as the carbon source. The fermentation medium used in the preliminary work with *Aspergillus nidulans* also contained lactose at a 2 per cent level. The medium used for this preliminary work, however, had been chosen because it was known to support penicillin production by the above *Penicillia*. Due to this fact it appeared quite possible that other carbon sources could support better yields when *A. nidulans* was the producing organism. With this in mind nineteen different carbon sources

TABLE 1

CARBON SOURCES

Carbon Source	Yield in mm. per day						
	3	4	5	6	7	8	9
whole ground corn	25.8	27.4	30.3	31.1	32.1	32.0	32.4
whole ground oats	18.0	24.0	29.1	29.4	32.0	32.7	32.1
whole ground wheat	22.2	25.8	28.2	29.0	32.1	31.0	30.2
whole ground barley	24.3	26.0	30.0	30.5	31.4	30.8	30.6
glycerine	26.7	27.5	28.8	27.7	29.8	29.8	29.4
d-xylose	0.0	0.0	0.0	18.4	24.0	25.7	27.3
d-arabinose	0.0	21.2	27.0	27.7	26.6	25.0	22.0
dextrose	18.4	21.1	24.7	26.5	24.5	28.1	27.7
mannite	27.7	28.3	26.8	26.6	29.1	28.9	28.4
d-galactose	19.4	22.7	25.9	28.1	31.0	29.9	29.3
honey	17.0	20.7	25.1	27.7	28.7	28.3	27.6
sucrose	16.6	20.0	24.8	25.3	28.3	27.7	28.0
maltose	19.7	22.7	23.7	25.9	28.7	28.1	27.9
lactose	25.8	27.0	27.3	28.3	30.5	30.0	29.7
brown sugar	11.7	17.6	20.6	24.7	26.3	27.0	
molasses	20.1	24.5	26.9	28.0	29.1	27.1	26.8
soluble starch	22.7	26.2	26.6	28.2	28.6	28.3	27.9
dextrin	21.3	22.1	26.7	27.2	28.9	28.6	27.2
sodium glycerophosphate	27.7	27.7	26.9	27.7	28.7	28.2	27.0
whey powder	25.1	27.4	28.6	28.3	27.2		

were substituted for lactose in the lactose corn steep medium plus salts. The results are given in Table 1.

The whole ground grains supported the best yields. There is no certainty, however, that this is due solely to the added carbon. Galactose and lactose were the best of the sugars tried, though some of the others supported yields which were almost as high. Use of glycerine and sodium glycerophosphate resulted in yields lower than those supported by lactose but the potencies came up much faster. This was also true for mannite. The production of penicillin on the various carbon substrates could be correlated with the pH changes. For example, use of d-xylose and d-arabinose, which resulted in low early potencies, also resulted in a slow rise in pH.

It is quite possible that different results would have been obtained if a higher rate of aeration had been used as well as a higher level of carbohydrate. The effect of aeration upon penicillin production when various carbohydrates are used has already been discussed (4). Indeed, the superiority of lactose for penicillin production, under the conditions frequently employed, appears to be due to the fact that the oxygen supply is near the oxygen demand for this sugar (5).

In order to investigate the effect of aeration and concentration a number of carbohydrates were chosen. Three of these, glycerine, sodium glycerophosphate, and mannite, resulted in an early rise in potency. Two others, whole ground corn and galactose, supported good yields but resulted in slow increase of penicillin. Lactose was also included. These materials were employed at 4 per cent concentration. Aeration was increased by using 50 ml. amounts of the fermentation medium in the Erlenmeyer flasks as compared with the 100 ml. previously used. The results are shown in Table 2.

TABLE 2

CARBON SOURCES

Carbon Source	Yield in mm. per day					
	3	4	5	6	7	8
whole ground corn						
4% in 100 ml.	21.6	25.9	25.6	25.2	25.2	
4% in 50 ml.	18.4	24.7	27.2	29.8	31.8	34.0
sodium glycerophosphate						
4% in 100 ml.	27.3	27.0	27.1	25.7	23.8	
4% in 50 ml.	26.5	26.6	26.4	24.8	22.3	
mannite						
4% in 100 ml.	21.0	27.1	28.0	26.0	25.9	
4% in 50 ml.	26.0	27.7	28.8	26.0		
glycerine						
4% in 100 ml.	15.9	25.9	27.9	28.5	26.8	
4% in 50 ml.	23.6	26.8	28.5	27.2	26.4	
galactose						
4% in 100 ml.	0.0	18.4	18.7	24.9	25.6	29.4
4% in 50 ml.	23.6	25.7	29.2	27.9	31.5	
lactose						
4% in 100 ml.	21.7	27.7	29.8	27.7	27.7	
4% in 50 ml.	24.7	27.7	28.6	26.2	25.7	

In comparably aerated fermentations none of the carbon sources at 4 per cent level resulted in greater yields than the same carbon source supported at 2 per cent level. In fact, in each case the penicillin level was lower. Increased aeration did not markedly increase the yields obtained with sodium glycerophosphate, glycerine, mannite, or lactose. The higher rate of aeration did result in better yields with whole ground corn and galactose, though with the former the peak came considerably later at the higher aeration. With some of the carbohydrates, an increased aeration exerts a striking effect on the rise in penicillin production. This effect is particularly noticeable when glycerine and galactose are used. It is somewhat noticeable with mannite and lactose.

As had been noted the best of the twenty substances tried were the whole ground grains, but the stimulation by these substances may not necessarily be due to the added carbon. If the level of corn steep is raised to 4 per cent, lactose supports yields higher than those obtained with the whole ground grains. Lactose was chosen over the whole ground grains for later work, not only because of this, but also because use of the whole ground grains in addition to corn steep would have resulted in a very complex medium.

Corn Steep Substitutes—The discovery (6) of the efficacy of corn steep liquor in increasing yields is one of the landmarks in the history of penicillin. The function of corn steep in penicillin production is varied. One of the reasons for its usefulness, however, appears to be due to the precursors it contains. In the following work none of the known precursors was added, but a number of organic materials were investigated as substitutes for corn steep. The supplements were added at 2 per cent levels and compared with corn steep (Amaizo spray dried) at 2 per cent, 4 per cent, and 6 per cent levels. The results are shown in Table 3.

Soy bean meal was the best of the substitutes tried. When grass juice powder was used as a substrate, however, the yields were only slightly lower. It is well known that materials such as corn steep and soy bean expeller meal vary greatly. It is quite possible that different results would have been obtained if other lots of these materials had been used. Striking results were obtained with corn steep solids at different concentrations. Highest yields were obtained with corn steep at a 4 per cent level. The 6 per cent level supported yields slightly better than those obtained with a 2 per cent level though the potencies came up more slowly at the higher concentration. This could perhaps be due to the fact that the

TABLE 3

CORN STEEP SUBSTITUTES

Substitute	Yield in mm. per day					
	3	4	5	6	7	8
yeast extract	24.8	25.8	24.6	25.3	25.1	
beef extract	20.6	20.9	21.1	19.3	19.7	
malt extract	12.2	17.9	18.9	20.2	18.4	
Bacto peptone	22.0	20.9	20.5	17.2	12.1	
Parke-Davis peptone	20.3	23.7	23.5	21.4	16.8	
Wilson peptone	20.3	21.7	22.4	20.8	17.1	
dry potatoes	19.9	22.0	26.3	26.4	26.8	24.4
liver powder 1:20	14.6	22.1	26.2	27.4	27.6	24.6
soy bean meal	26.5	28.1	28.4	29.3	28.0	25.6
grass juice powder	24.2	26.4	27.9	28.5	27.4	
fish meal	24.4	26.4	27.3	27.7	27.7	25.1
asparagus butt juice	0.0	0.0	13.4	19.2	20.6	18.9
corn steep solids (2%)	23.1	25.9	29.9	30.7	30.7	27.9
corn steep solids (4%)	20.1	28.3	32.9	33.6	34.2	
corn steep solids (6%)	0.0	18.3	21.7	28.0	31.8	30.1

fermentation remained acid too long as a result of the high concentration of lactic acid in the corn steep.

Results, as those given above, are difficult to evaluate if only the *Staphylococcus aureus* assay yields are given. Various organic supplements contain different amounts of the various penicillin precursors. If the metabolism solutions, from fermentations in which these organic supplements are used, are not analyzed for the changing content of the different penicillins it is difficult to determine the worth of the material added.

In addition the corn steep apparently contains the salts and heavy metals necessary for growth and penicillin production by *Aspergillus nidulans.* On a medium containing 2 per cent lactose and 4 per cent corn steep, yields were as good or better when salts were omitted than when they were added.

Chemical Changes Occurring in the Medium During Fermentation—The chemical changes occurring in the medium during fermentation were determined daily on composite samples obtained by combining the contents of three Erlenmeyer flasks. The mycelium was filtered off, dried at 80° C. for 48 hours, then weighed. The pH of the filtrate was determined with a glass electrode and the penicillin content measured by the cylinder plate method. Lactose content of the filtrate was determined by Somogyi's copper reduction method after the samples were hydrolyzed in 1 N HCl by autoclaving at 15 lbs. pressure for 30 minutes; readings were made from a curve based on pure lactose. The total nitrogen was determined by the Kjeldahl method. Nitrate nitrogen was determined by reduction to ammonia in the presence of DeVarda's alloy in hot alkaline solution, and ammonium nitrogen by alkaline cold aeration for four hours. The total organic nitrogen is Kjeldahl nitrogen minus ammonium nitrogen.

The changes occurring during the fermentation are shown in Table 4.

TABLE 4

CHEMICAL CHANGES OCCURRING IN THE MEDIUM DURING FERMENTATION

Factor Determined	0	1	2	3	4	5	6	7	8
Lactose per cent remaining	100.0	97.0	83.4	68.5	51.0	33.0	30.0	18.0	18.0
NO_3-N per cent remaining	100.0	71.0	60.5	63.8	72.2	38.8	32.9	33.5	33.5
NH_3-N per cent remaining	100.0	6.6	8.4	19.2	150.0	191.0	231.0	200.0	178.0
Organic N per cent remaining	100.0	98.2	98.2	92.9	81.3	50.9	56.3	55.4	55.0
Mycelium mg./ml.	0.0	0.8	1.3	24.3	49.0	56.5	56.5	56.5	50.0
Penicillin zones in mm.	0.0	0.0	11.0	23.3	34.0	36.0	38.5	37.0	37.0
pH	3.5	3.8	4.4	6.1	7.1	7.2	6.9	7.8	7.8

Changes in pH. The pH rises slowly the first two days, then rapidly the third and fourth days. From the fourth day on a pH plateau between 7.0 and 8.0 is maintained. It may also be noted that coincident with the increase in pH there is a large increase in the dry weight of mycelium and a rise in penicillin production.

The rise in pH may be attributed to several factors. Ammonia accumulation appears to be one of these. The ammonia apparently arises from deamination of organic nitrogen compounds of the corn steep as well as from reduction of nitrate nitrogen. Another contributing factor to this pH rise is probably the utilization of lactic acid supplied in the corn steep. In addition the utilization of nitrate ions with the subsequent release of sodium ions would contribute to this pH rise.

Changes in the Dry Weight of Mycelium. Most of the mycelium is formed during the first four days coincident with the increase in pH. After the pH plateau is reached there is little increase in mycelium weight. This is in line with what has been found with *Penicillium notatum,* when grown in the same medium, where it has been shown that mycelial growth occurs rapidly at low pH values while little increase in dry weight occurs at neutrality (7). In the fermentations carried out with *Aspergillus nidulans,* the mycelial carbon appears to come from lactose as well as the corn steep. Whereas the lactose is utilized quite rapidly from the second until the sixth day, it is not exhausted at the end of eight days. The rapid increase in mycelium coincident with the increase in ammonium nitrogen and only a slight decline in nitrate nitrogen indicates that the mycelial nitrogen comes from the organic nitrogen compounds of the corn steep.

From four to seven days there is little apparent gain in mycelium weight; autolysis, as revealed by dry weight measurements, begins at seven days. Autolysis may occur earlier, however, a possibility which is supported by the fact that the total organic nitrogen increases somewhat on the sixth day and remains relatively unchanged throughout the eighth day. This increase in organic nitrogen on the sixth day could be due to organic nitrogen being liberated by the autolyzing mycelium.

Changes in Penicillin Content of the Medium. Rise in penicillin production starts about the second day and increases rapidly until the fourth day at which time it levels off. The greatest penicillin production comes at the time of the pH plateau, with the maximum appearing slightly before the apparent autolysis of the mycelium. This may indicate release of penicillin by autolysis, a possibility which was investigated as follows. The metabolism solution was decanted from seven day old fermentations, the mycelium of which was ready to autolyze. Upon assay this metabolism solution produced zones of 32.0 mm. Sterile phosphate buffer at pH 7.0 was added to each flask and the pellets thoroughly washed. This buffer was then decanted and replaced with 100 ml. of fresh sterile buffer. The flasks were replaced on the shaker and assayed at 24 and 48 hours. After 24 hours, the solution produced zones of 29.0 mm. and after 48 hours, zones of 33.0 mm. After 48 hours, then, the autolyzing mycelium had liberated more penicillin than was contained in the seven day old metabolism solution.

DISCUSSION

Metabolism solutions of *Penicillium notatum* and *P. chrysogenum* have been shown to contain a number of penicillins. Some of these have been chemically characterized, and it is quite possible that other as yet unidentified ones exist. As noted before (1) the type of penicillin being produced by *Aspergillus nidulans* has not been determined. Two penicillins produced by other species of *Aspergillus,* however, have been identified. Gigantic acid, produced by *A. giganteus,* is pentylpenicillin (8), whereas flavicidin (3), a metabolic product of *A. flavus,* is Δ3-pentenylpenicillin. The latter organism also appears to produce some G penicillin. There is no reason to assume that the antibiotic activity produced by *A. nidulans* is due to only one type of penicillin. It is quite possible that the metabolism solution will be found to contain several penicillins depending upon the constituents of the medium as well as upon the strain used. The possibility also exists that *A. nidulans* is producing an antibiotic that has not as yet been chemically or biologically identified. Whatever the situation, the highest yield obtained in terms of penicillin units, when the above fermentation conditions were employed, was 20 u/ml. It has been shown, however, that the addition of a penicillin precursor such as a phenyl acetyl derivative will greatly stimulate production by this species (1). The synthetic medium of Stone and Farrell (10) also supported yields equivalent to those obtained on the unsupplemented lactose corn steep medium (1).

Yields could probably be increased by means of induced mutation and strain selection. Preliminary investigation, however, indicates that strain selection alone does not offer much hope. Observations of 1,000 monoconidial lines showed the organism to be quite stable as to morphology and antibiotic production. This might not be the case if other isolates from nature were used. In addition *A. nidulans* readily produces perithecia in culture. It is quite possible that single ascospore selection would result in greater variability. Breeding for greater productivity would be complicated by the fact that the organism is homothallic.

SUMMARY

1. The statement is made that *Aspergillus nidulans* produces penicillin in both surface and submerged fermentations.

2. Evidence for this statement includes: *a,* inactivation by penicillinase; *b,* method of extraction; *c,* inactivation by hydroxylamine; *d,* inactivation by copper sulphate; *e,* instability at low and high pH; *f,* solubility in various organic solvents; *g,* antibacterial activity.

3. Of the twenty carbon sources investigated, the whole ground grains supported the best yields. Exclusive of the whole ground grains, lactose and galactose were the best carbon sources. The maximum yield and the time the peak was reached depended upon the concentration of carbon and the amount of aeration. The effect of concentration and aeration varies with the carbon source.

4. No substitute as good as corn steep was found. Soy bean meal was the best of the substitutes among the substances investigated. Corn steep at a 4 per cent concentration, when used with a 2 per cent concentration of lactose, supported the highest yields.

5. The chemical changes occurring during fermentation were studied.

6. The highest yield obtained was equivalent to 20 u/ml. of penicillin.

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PENICILLIN PRODUCTION BY THE ASPERGILLUS NIDULANS GROUP

EUGENE L. DULANEY[1]

A number of species of *Penicillium* and *Aspergillus* have been shown to produce penicillin or penicillin-like substances. Within the genus *Penicillium*, the ability to produce penicillin appears to be characteristic of the *P. notatum-chrysogenum* group or of closely related species (12). Thus far, among the *Aspergilli*, this ability appears to be more widely distributed except possibly for the *A. flavus-oryzae* group (12). While the substances produced by these species of *Aspergillus* have been given various names, they appear on the basis of their biological characteristics to be closely related to penicillin. The substance produced by *A. flavus*, which has been called flavicin (2) or flavicidin (8) (9), has been chemically characterized, provisionally, as an F type penicillin, in which the double bond is in the $\Delta 3$ position (6). Gigantic acid, a metabolic product of *A. giganteus* (10), is dihydro-F penicillin (11). In addition *A. flavus* appears to produce small amounts of penicillin G (6). *A. oryzae* (5) (14) and *A. parasiticus* (3), two species closely related to *A. flavus*, also produce substances closely related to penicillin. White (15) and Foster and Karow (5) list *A. flavipes* as being capable of producing penicillin and the latter workers also report a strain of *A. niger* (5) as producing a similar substance. In addition the metabolism solutions of two members of the *A. nidulans* group, *i.e. A. nidulans* (1) (4) (5) and *A. caespitosus* (1), contain penicillin-like substances.

With the exception of five strains, all of the cultures used in this survey were members of the Merck culture collection. One strain of *Aspergillus nidulans* was isolated from compost and two strains each of *A. variecolor* and *A. caespitosus* were obtained from K. B. Raper. The nomenclature employed follows that in a *Manual of the Aspergilli* by Thom and Raper.

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[1] Research Laboratories of Merck & Co., Inc., Rahway, N. J.

Cultures grown on honey peptone agar slants were used as inoculum. Ten milliliters of sterile distilled water were added to seven day old slants, a spore suspension prepared, and one ml. of this suspension added to each flask. The production medium contained the following ingredients in grams per liter of distilled water: corn steep 30 grams, lactose 20 grams, and calcium carbonate 10 grams. The medium was dispensed in 50 ml. amounts in 250 ml. Erlenmeyer flasks which after sterilization and inoculation were placed on a rotary type shaker moving at 175 r.p.m. The incubation temperature was 24° C. The flasks were sampled at three and six days and the metabolism solutions were assayed against *Staphylococcus aureus* by the cylinder plate method. The results are presented in Table 1.

TABLE 1

SURVEY OF 45 STRAINS OF THE ASPERGILLUS NIDULANS GROUP

Species	No. of Strains Tested	No. of Strains Active
Aspergillus nidulans	19	16
A. quadrilineatus	3	3
A. rugulosus	8	3
A. unguis	7	6
A. variecolor	6	6
A. caespitosus	2	2

It can be seen that a majority of the strains were active. With the exception of the *Aspergillus nidulans* strains, one strain of *A. quadrilineatus* and two strains of *A. rugulosus*, the amount of antibiotic produced was only a fraction of one unit. This low level of activity made further experimentation difficult with most of the strains.

Twenty of the most active strains were selected for further study. These included fifteen species of *Aspergillus nidulans,* two of *A. quadrilineatus* and three of *A. rugulosus.* Four day old metabolism solutions of these strains were subjected to a number of tests in order to determine if the activities were due to penicillin-like substances. The results are given below.

ANTIBACTERIAL ACTIVITY. The metabolism solutions were active against *Staphylococcus aureus* but inactive against *Escherichia coli* and penicillin-resistant *S. aureus*. In addition the antibacterial spectrum of one strain has been compared to that of *Penicillium notatum* 832 and been found to be quite similar.

INSTABILITY AT LOW AND HIGH pH. Portions of the metabolism solutions were adjusted to pH 2.0–2.5 with 1 N HCl and other portions adjusted to pH 10.0–11.0 with 1 N NaOH. After incubation for four hours at 28° C. they were readjusted to approximate neutrality and assayed. In each case the antibiotic activity had either completely disappeared or was greatly diminished.

INACTIVATION BY HYDROXYLAMINE. Hydroxylamine completely inactivated the metabolism solutions after incubation at 28° C. for four hours.

INACTIVATION BY COPPER SULPHATE. Copper sulphate, at a level which did not inhibit *Staphylococcus aureus*, completely inactivated the metabolism solutions after incubation for four hours at 28° C.

ENZYMATIC INACTIVATION. An enzyme preparation which inactivated penicillin, completely inactivated these metabolism solutions after incubation at 37° C. for three hours.

In addition to the above, one strain of *Aspergillus nidulans* has been studied more intensively. The results of this work will be reported at a later date.

Preliminary results indicated that the highest levels of activity were being obtained from strains of *Aspergillus nidulans*. Five of the most active strains were selected for a comparative test on three media: namely, the corn steep (C. S.) medium as given above, the corn steep medium supplemented with a phenyl acetyl derivative at 0.1 per cent level (7), and the synthetic medium of Stone and Farrell (13). The results are presented in Table 2.

It is quite obvious that use of the supplemented corn steep medium resulted in yields significantly better than those produced on the unsupplemented corn steep medium. In addition strains MF 116 and MF 118 produced yields on the synthetic medium which were significantly higher than those produced on the unsupplemented corn steep medium. The synthetic and unsupplemented corn steep media served equally well for production by MF 119, but the unsupplemented corn steep was slightly superior for strains MF 126 and MF 572.

TABLE 2

COMPARATIVE YIELDS OF FIVE SELECTED STRAINS OF ASPERGILLUS NIDULANS

Strain	Medium	Maximum Yield *S. aureus* Units	Day of Maximum
MF 116	corn steep	11.0	4
	C. S. supplemented	21.0	5
	synthetic	18.0	4
MF 118	corn steep	9.7	4
	C. S. supplemented	21.0	5
	synthetic	14.0	4
MF 119	corn steep	17.0	5
	C. S. supplemented	50.0	5
	synthetic	17.0	5
MF 126	corn steep	15.5	4
	C. S. supplemented	34.0	5
	synthetic	12.0	5
MF 572	corn steep	14.0	5
	C. S. supplemented	21.0	5
	synthetic	11.0	5

The strains used in this survey were from widely different sources. Within the species, the number of strains investigated, with the exception of *Aspergillus nidulans,* was not great, but from the results it would appear that metabolism solutions of species of the *Aspergillus nidulans* group characteristically contain antibiotic factors, even if in small amounts. In addition, results indicate that these factors are closely related to penicillin. Strains of *A. unguis, A. variecolor,* and *A. caespitosus,* while showing activity, were omitted from the later tests because the activity was at such a low level. The latter species, however, has been shown to produce penicillin (1).

It is not clear whether the antibiotic activity of these strains is due to one or more of the now known penicillins, to one or more unknown penicillins, or to a mixture of known and unknown penicillins. The penicillins produced would probably vary with the strain and constituents of the medium. In addition factors other than penicillins may be produced.

While the relatively low levels of activity would seem to eliminate these organisms from commercial consideration, the chemical nature of the active factor(s) should prove interesting.

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THE GROWTH OF FUNGI ON ASPHALT-TREATED PAPER

W. D. Gray and G. W. Martin[1]

(with 7 figures)

The use of asphalt-coated paper to protect the contents of boxes containing materials which might be injured by moisture or molds is very extensive. There seems to be a wide-spread impression that asphalt is itself a fungicide. In view of the very great variability in the substances marketed as asphalt it is quite possible that some asphalts do incorporate materials which are fungicidal, but the studies here reported demonstrate that this cannot be taken for granted.

Several asphalt-treated L-2 Type Case Liners were sent to the Biological Laboratory of the Jeffersonville Quartermaster Depot for study. These were variously spotted (figs. 1 and 2) with what were obviously fungous growths. Isolations made from these spots yielded nineteen different fungi. These were identified at least as to genus and were assigned culture numbers as follows:

Penicillium (*fasciculata* group): J688; J689
Penicillium (*asymmetrica-velutina* group): J677
Penicillium (*biverticillata-symmetrica* group): J697; J699
Penicillium (*lanata typica* group): J698
Aspergillus (*flavus-oryzae* group): J674
Aspergillus (*versicolor* group): J686; J687; J695
Aspergillus (*fumigatus* group): J675
Aspergillus spp.: J694; J673; J696; J589
Chaetomium sp.: J647
Sepedonium sp.: J645
Trichoderma sp.: J646
Chaetomium globosum: no number assigned

Since the isolation work had shown that the L-2 Type Case Liner material involved would support the growth of a number of fungi, it seemed advisable to obtain materials of this nature from various firms and determine if they would also support fungus

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[1] Formerly of Jeffersonville Quartermaster Depot. Publication authorized by Office of Quartermaster General.

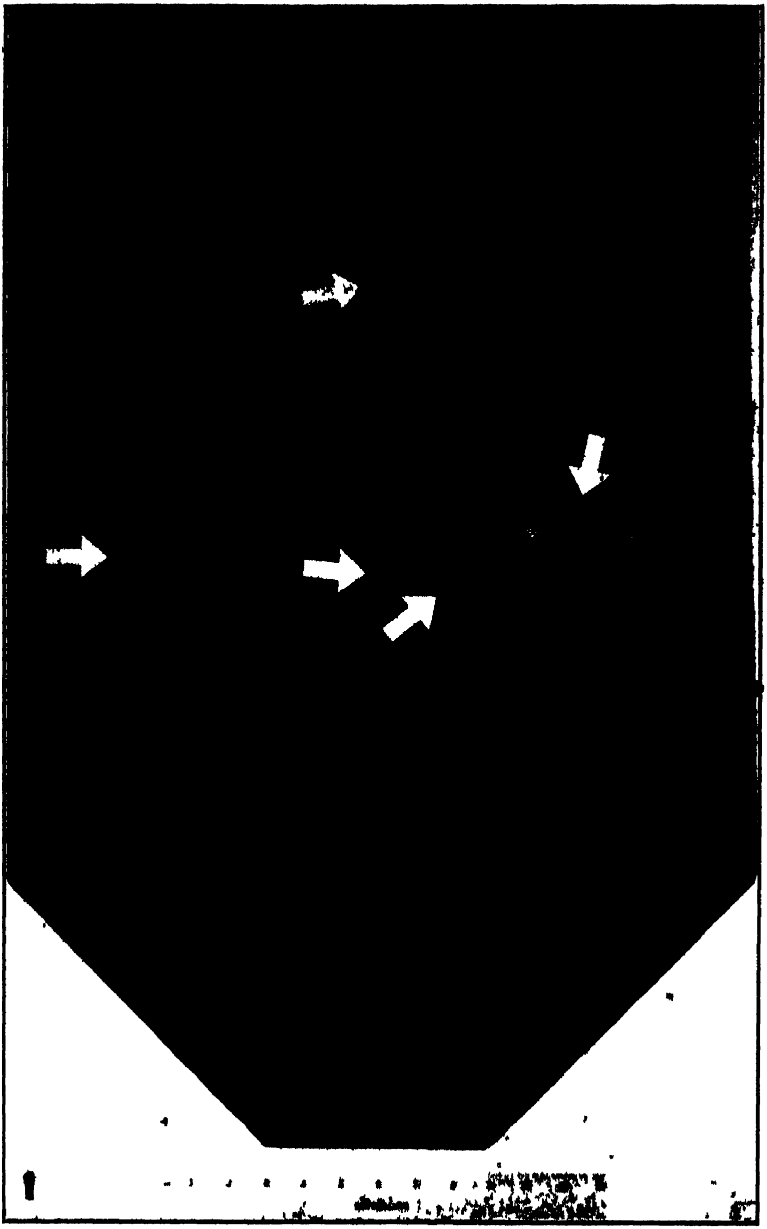


FIG. 1. L-2 Type Case Liner showing fungous spotting.

growth. Accordingly, finished case liner materials, kraft paper, and both infusion and laminating asphalt were obtained from three different sources in order that these materials might be tested to determine if they were subject to fungus attack. In addition to these materials, creped kraft paper treated with Dowicide G, ranging in concentration from 0.7 to 1.6 per cent, was also obtained and subjected to test.

EXPERIMENTAL PROCEDURE. The method generally employed for testing finished liner material, asphalt-infused paper, laminated paper, and plain or creped kraft paper was to cut test squares (2 inches × 2 inches), sterilize them by autoclaving, and then transfer each test square to a petri dish containing sterile nutrient salt agar. Inoculations were made by placing a small drop (1–2 mm. diameter) of sterile distilled water in the center of each square and introducing spores of a single species of fungus into the drop; the inoculated plates were then incubated in a room in which the temperature and humidity were controlled at 85° F. and 85 per cent R.H.

Samples of asphalt were tested as follows: small spheres (*ca.* 5 mm. diameter) were placed in the centers of 1 × 3 inch microscope slides; each slide was then heated over a low flame and was rocked gently until an area of approximately one square inch was covered with asphalt. The slides with asphalt were then sterilized by autoclaving and placed on the surface of nutrient salt agar in petri dishes. Inoculations were made by introducing spores into a small drop of sterile distilled water placed in the center of the asphalt film. In one instance the sample of asphalt was not in the solid state, so it was simply autoclaved, and small amounts were placed on the surface of sterile nutrient agar in petri dishes and allowed to spread; inoculations were then made as described above.

RESULTS. Firm No. 1 supplied samples of its finished asphalt-treated paper which consisted of an asphalt-saturated sheet of smooth kraft paper laminated to a sheet of unsaturated smooth kraft paper. This firm also supplied samples of saturating asphalt and laminating asphalt. Samples of liner material and asphalt were inoculated with several organisms isolated from the original defective liners, incubated, and observed at five- and ten-day intervals. Results obtained with these materials are presented in Table I. A

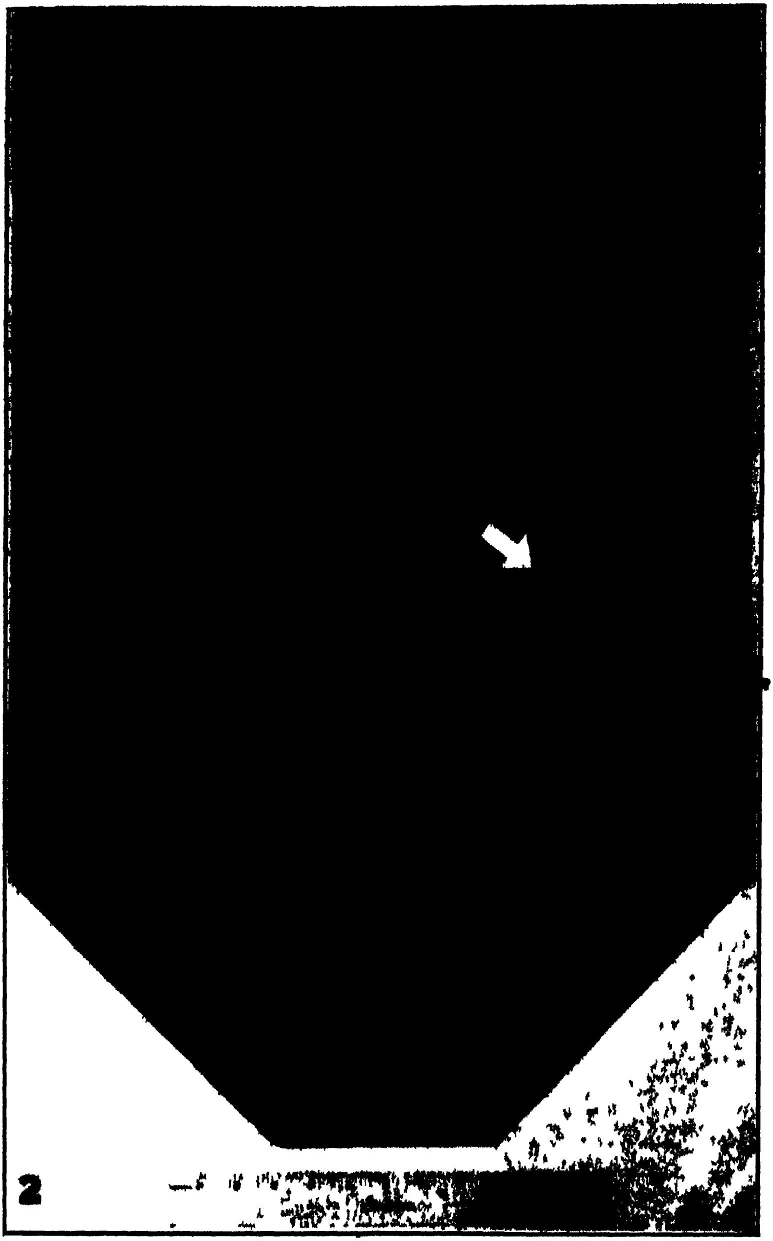


FIG. 2 Reverse side of the liner shown in first figure.

TABLE I

GROWTH OF FUNGI ON MATERIALS SUPPLIED BY FIRM NO. 1

Organism	Culture No.	Growth*					
		Finished Product		Saturating Asphalt		Laminating Asphalt	
		5-day	10-day	5-day	10-day	5-day	10-day
Penicillium	J688	x	xx	x	x	–	–
Aspergillus	J686	–	x	x	x	–	–
Aspergillus	J675	x	xxx	x	x	–	x
Aspergillus	J674	x	xxxx	–	x	–	xx
Penicillium	J689	x	xx	x	x	–	–
Chaetomium	J647	x	xxxx	x	x	x	x
C. globosum	—			x	x	x	x
Sepedonium	J645	–	xx	–	–	x	x

* In this and all subsequent tables the following designation is used:

– no growth
x up to ¼ of total area covered
xx ¼ to ½ of total area covered
xxx ½ to ¾ of total area covered
xxxx over ¾ of total area covered

photograph of a test square of the finished liner material, inoculated with *Chactomium* sp. (J647), is presented in Figure 3. This photograph was taken nine days after inoculation.

Firm No. 2 supplied two types of material: (1) the finished product, which was laminated, two-ply, asphalt-coated, creped kraft paper, and (2) two sheets laminated with asphalt but not coated or creped. Results obtained with these materials are listed in Table II.

TABLE II

GROWTH OF FUNGI ON MATERIALS SUPPLIED BY FIRM NO. 2

Organism	Culture No.	Growth			
		Finished Product		Laminated Only	
		5-day	10-day	5-day	10-day
Penicillium	J688	–	–	–	x
Aspergillus	J686	x	x	x	x
Aspergillus	J675	x	xxxx	x	xxxx
Aspergillus	J674	xx	xxxx	xxx	xxxx
Penicillium	J689	–	x	x	x
Chaetomium	J647	x	xxxx	–	xx
C. globosum	—	x	xxxx	x	xxx
Sepedonium	J645	x	x	x	x

Firm No. 3 supplied the following materials: (1) finished product (two-ply, asphalt-treated, laminated, both sheets creped), (2) same as the preceding except that the uninfused sheet was a smooth kraft paper, (3) single, creped, asphalt-infused sheet, (4) smooth, untreated kraft paper, (5) creped, untreated kraft paper, (6) infusion asphalt, and (7) laminating asphalt. Results obtained from tests conducted with these materials are presented in Tables III and IV; photographs made nine days after inoculation are shown in Figures 4, 5, and 6.

TABLE III

GROWTH OF FUNGI ON PAPER AND PAPER-PRODUCTS SUPPLIED BY FIRM NO. 3

(Observations made ten days after inoculation)

Organism	Culture Nö.	Growth				
		Finished (Plain-back)	Finished (Creped back)	Infused sheet	Smooth Kraft	Creped Kraft
Penicillium	J688	xx	x	x	x	xx
Aspergillus	J686	x	x	x	x	x
Aspergillus	J675	xxxx	xxxx	xxxx	xxxx	xxxx
Aspergillus	J674	xxxx	xxx	xxxx	xxxx	xxxx
Penicillium	J689	xx	x	xx	xxx	xx
Chaetomium	J647	xxxx	x	xxxx	xxxx	xxxx
C. globosum	—	xxxx	x	xxxx	x	xxxx
Sepedonium	J645	x	x	x	x	x

TABLE IV

GROWTH OF FUNGI ON ASPHALTS SUPPLIED BY FIRM NO. 3

Organism	Culture No.	Laminating Asphalt		Infusion Asphalt	
		5-day	10-day	5-day	10-day
Penicillium	J688	–	x	–	x
Aspergillus	J686	–	x	–	x
Aspergillus	J675	–	x	x	x
Aspergillus	J674	–	–	–	x
Penicillium	J689	x	x	–	–
Chaetomium	J647	–	–	x	x
C. globosum	—	x	x	x	x
Sepedonium	J645	–	–	x	x

From the results presented in Tables I–IV, it is obvious that all of the constituent materials of L-2 Type Case Liners which were tested are capable of sustaining the growth of a number of fungi.

Whether or not the paper is appreciably damaged by all of the fungi which have been shown to be capable of growing on it cannot be accurately determined by observations of the type described above; hence, a number of the organisms employed in these studies were examined from the standpoint of their cellulose-destroying abilities. This was determined by measuring changes in tensile strength of gray duck inoculated with various of these organisms. Strips of 12.29 oz. gray duck (1½ × 5½ inches, warp threads in the long dimension) were ravelled to a width of one inch; each strip was

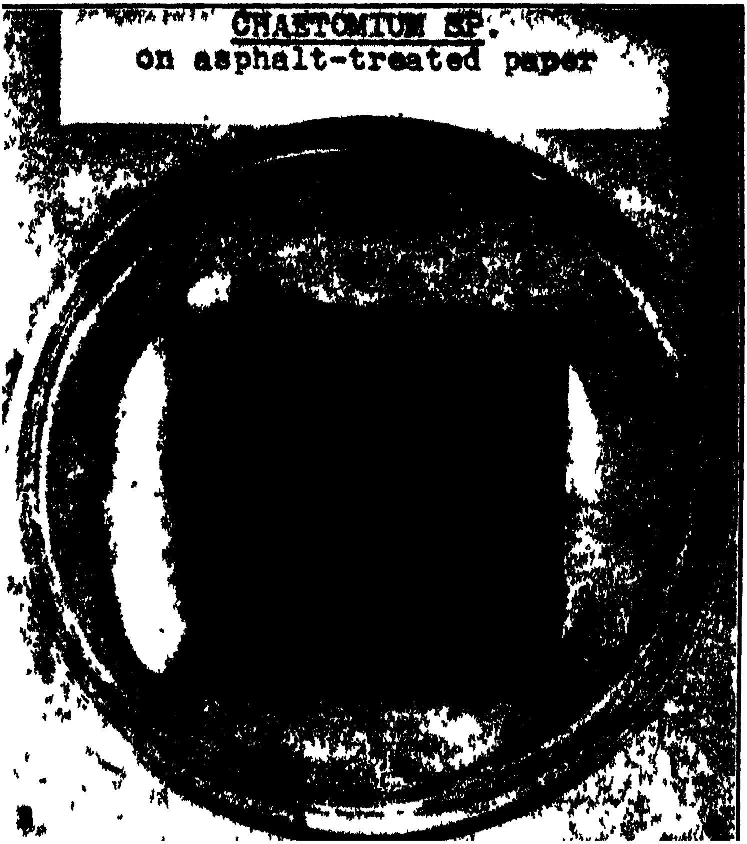


FIG 3 Growth of *Chaetomium* sp (J647) on finished liner material Photographed nine days after inoculation

then placed in a 1 × 8 inch test tube containing 10 ml. of nutrient salt solution and sterilized by autoclaving. Each strip was inoculated by streaking spores in a single vertical line about one inch long near the middle of the strip; ten replicate strips were inoculated with each fungus tested. After seven days incubation at 85° F. and 85 per cent R.H. the strips were washed, dried, and then conditioned for 24 hours at 72° F. and 65 per cent R.H. prior to breaking. The strips were broken on a 0–250 lbs. Scott testing machine. Results of tensile strength determinations are listed in Table V.

TABLE V

CHANGE IN TENSILE STRENGTH OF 12.29 OZ. GRAY DUCK INOCULATED WITH FUNGI WHICH HAD BEEN ISOLATED FROM DEFECTIVE L-2 TYPE CASE LINERS

Organism	Culture No.	Average Tensile Strength	Per Cent Change in Tensile Strength
Penicillium	J688	171.2	3.4% loss
Aspergillus	J686	182.0	2.5% gain
Aspergillus	J675	110.3	37.8% loss
Aspergillus	J674	142.9	19.4% loss
Penicillium	J689	162.8	8.1% loss
Aspergillus	J687	166.5	6.1% loss
Chaetomium	J647	61.3	65.4% loss
Sepedonium	J645	133.7	24.6% loss
Trichoderma	J646	62.1	36.8% loss
Uninoculated controls		177.2	

The results in Table V show that many of the fungi which can grow on asphalt-treated paper are capable of destroying cellulose and hence can damage the paper very appreciably. It should be noted that the ten strips inoculated with *J686* showed an average gain in tensile strength of 2.5 per cent. No especial significance should be attached to this fact other than that this fungus is incapable of attacking cellulose under the conditions of the test. The slight apparent gain in tensile strength was probably due either to variations in the tensile strength of the original cloth or to a slight shrinkage and tightening of the fibers during the course of the test.

Since all of the materials tested were shown to be susceptible to attack by various fungi, paper into which a fungicide was incorporated was obtained and subjected to test. Four lots of such paper were received; these contained 0.7, 0.9, 1.2, and 1.5 per

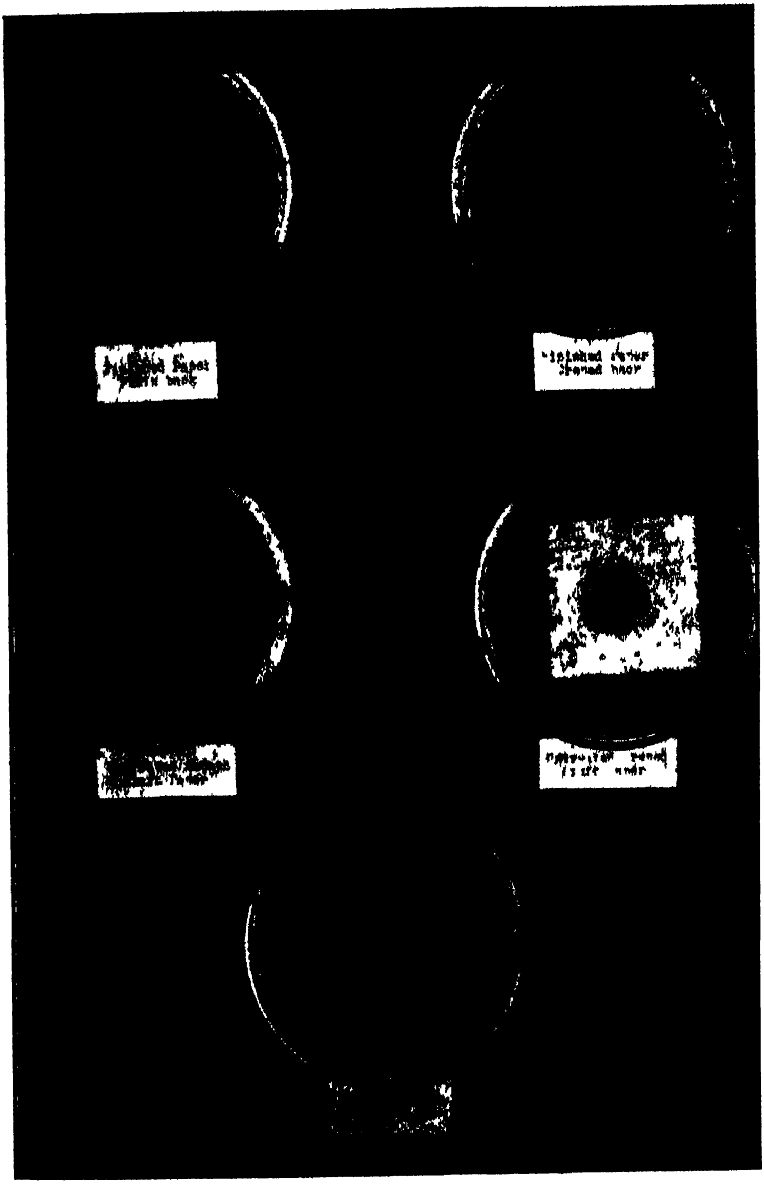


FIG. 4. Growth of *Penicillium* sp. (J674) on materials supplied by Firm No. 3.

cent Dowicide G, respectively. In the preliminary experiment both sterilized and unsterilized test squares of treated paper were inoculated with nine test organisms. Test squares of sterilized, untreated, creped kraft paper supplied by Firm No. 3 were used as controls. After ten days incubation the test squares were examined, and the controls were found to have supported growth of all the fungi tested. There was no growth on either the sterilized or non-sterilized samples containing Dowicide G, as is illustrated by Figure 7.

Test squares of fungicide-containing papers were next leached in running water for 24 hours; they were then dried, sterilized and inoculated. Three test squares from each lot were then inoculated with *Chaetomium sp.* (J647), three with *C. globosum*, and six with enriched soil suspension. After ten days incubation only one test square in twelve of the paper which contained 1.5 per cent inhibitor prior to leaching supported fungus growth. This was true of the paper containing 1.2 per cent inhibitor, whereas the papers originally containing 0.7 and 0.9 per cent inhibitor supported fungus growth in over one-half of the test plates. When the various papers were subjected to leaching for a one hundred and twenty hour period, enough inhibitor was removed to permit fungus growth on all test squares. These experiments demonstrate that whereas Dowicide G may protect paper if present in a concentration of 0.7 per cent or higher, it may be leached from the paper rather readily. The fact that this inhibitor is not fast to leaching would probably be unimportant if the paper containing it was infused or coated with asphalt.

In spite of the fact that kraft paper can be treated with Dowicide G and thus rendered mildew-resistant, the question arises as to whether or not paper containing an inhibitor can support fungus growth when infused or coated with asphalt not containing an inhibitor. Accordingly, materials were prepared in order to answer this question. Both paper containing Dowicide G and untreated paper were infused with plain asphalt and asphalt containing 3 per cent pentachlorophenol. One inch square test strips were used; these were dipped in a solution of 5 gms. of asphalt dissolved in 25 ml. of ethyl ether. After dipping, the test squares were dried in a vacuum oven for four hours. When inhibitor was

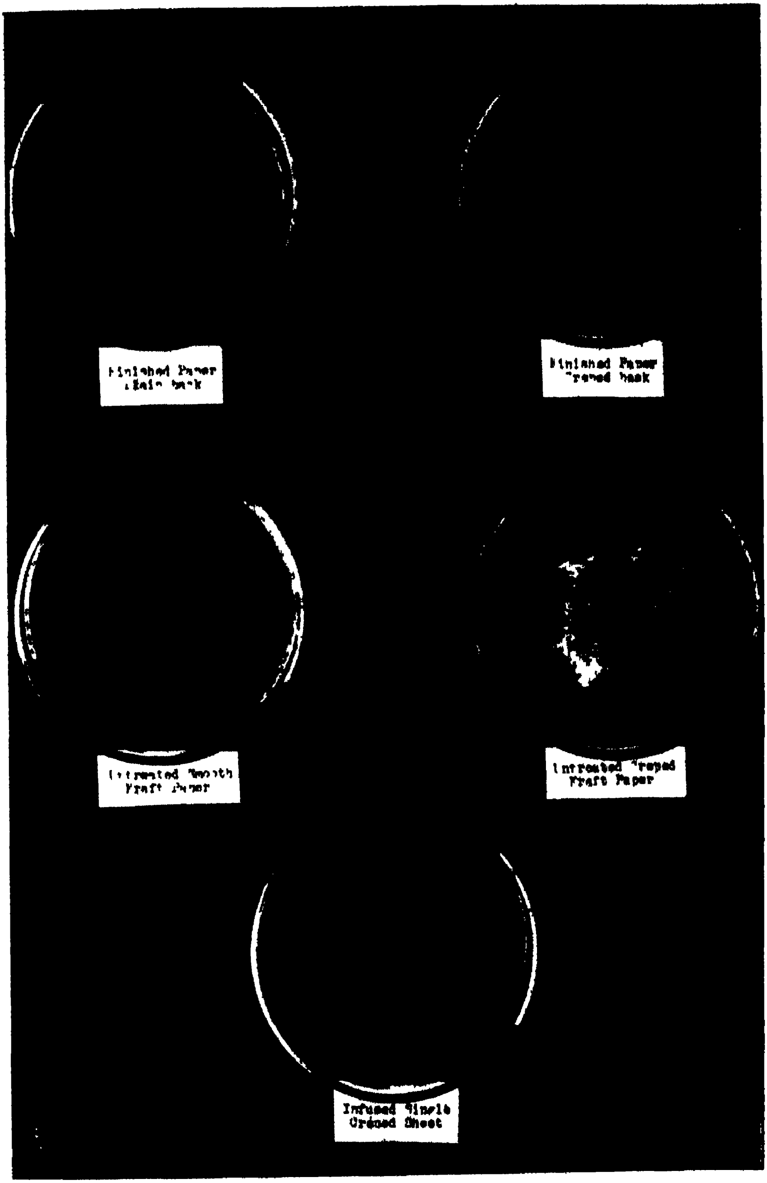


FIG. 5. Growth of *Aspergillus* sp. (J675) on materials supplied by Firm No. 3.

incorporated in the asphalt, 0.15 gm. of pentachlorophenol was dissolved in the ether-asphalt solution. The following types of samples were prepared:

1. Treated paper infused with untreated asphalt.
2. Untreated paper infused with treated asphalt.
3. Untreated paper infused with untreated asphalt and laminated to treated paper with the same type of asphalt.
4. Treated paper infused with treated asphalt.

Sterilized and unsterilized samples of the above materials were inoculated and observed after a ten day incubation period. Since no differences appeared between sterilized and unsterilized samples, only the results obtained with unsterilized samples are presented in Table VI.

TABLE VI

GROWTH OF FUNGI ON VARIOUS COMBINATIONS OF TREATED AND UNTREATED PAPER WITH TREATED AND UNTREATED ASPHALTS

Organism	Culture No.	Paper: 1.6% Dowicide G; Asphalt: untreated	Paper: untreated; Asphalt: 3% pentachlorophenol	Untreated paper infused and laminated to treated paper with untreated asphalt.	Paper: 1.6% Dowicide G; Asphalt: 3% pentachlorophenol
Penicillium	J688	x	–		–
Aspergillus	J686	xxx	–		–
Aspergillus	J675	xx	–		–
Aspergillus	J684	xx	–	xx	–
Penicillium	J689	xx	–	x	–
Chaetomium	J647	x	–	x	–
Sepedonium	J645	x	–	x	–
Trichoderma	J646	xx	x	xxx	–

DISCUSSION AND CONCLUSIONS. On the basis of the above studies it may be concluded that a large number of fungi are able to grow on asphalt-treated paper or its component materials. Of the various materials tested, none was found that is naturally resistant to fungus attack. Some of the fungi involved are capable of attacking cellulose (as evidenced by loss of tensile strength by 12.29 oz. gray duck); others appear to be merely surface growers. While members of the genus *Aspergillus* are ordinarily considered surface growers, it should be noted that one species of *Aspergillus* (J675) was able to reduce the tensile strength of gray duck 37.8 per cent in one week.

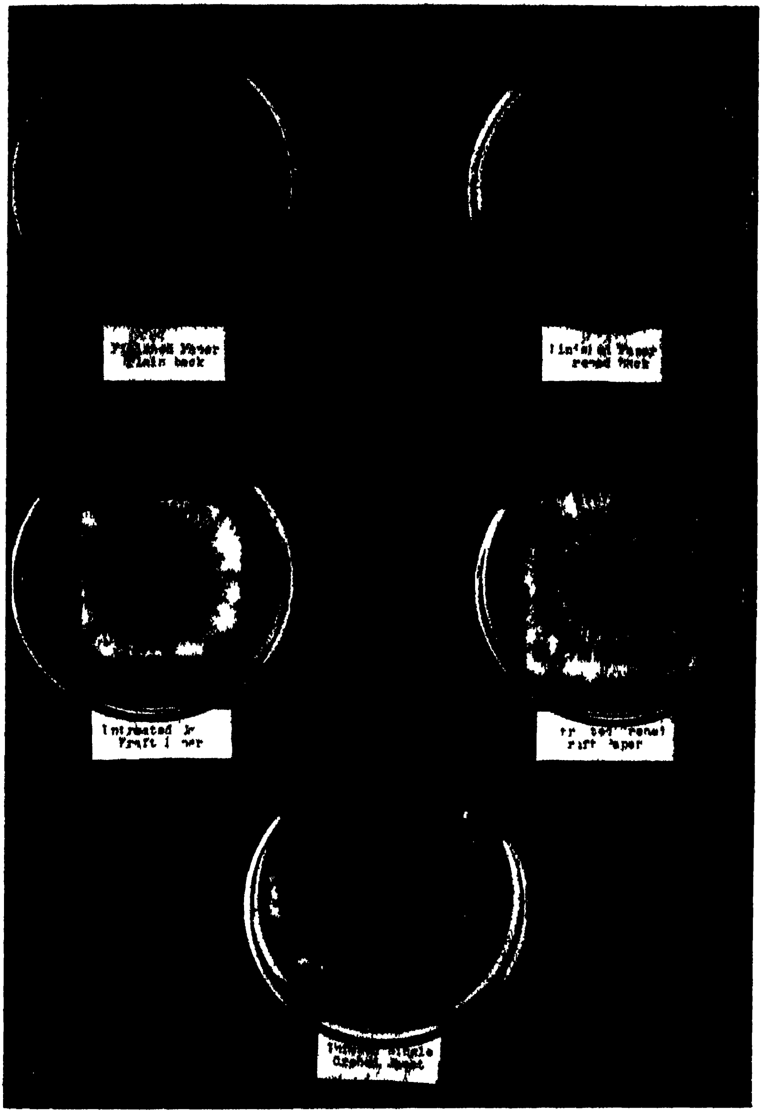


FIG 6 Growth of *Chaetomium* sp (J647) on materials supplied by Firm No 3

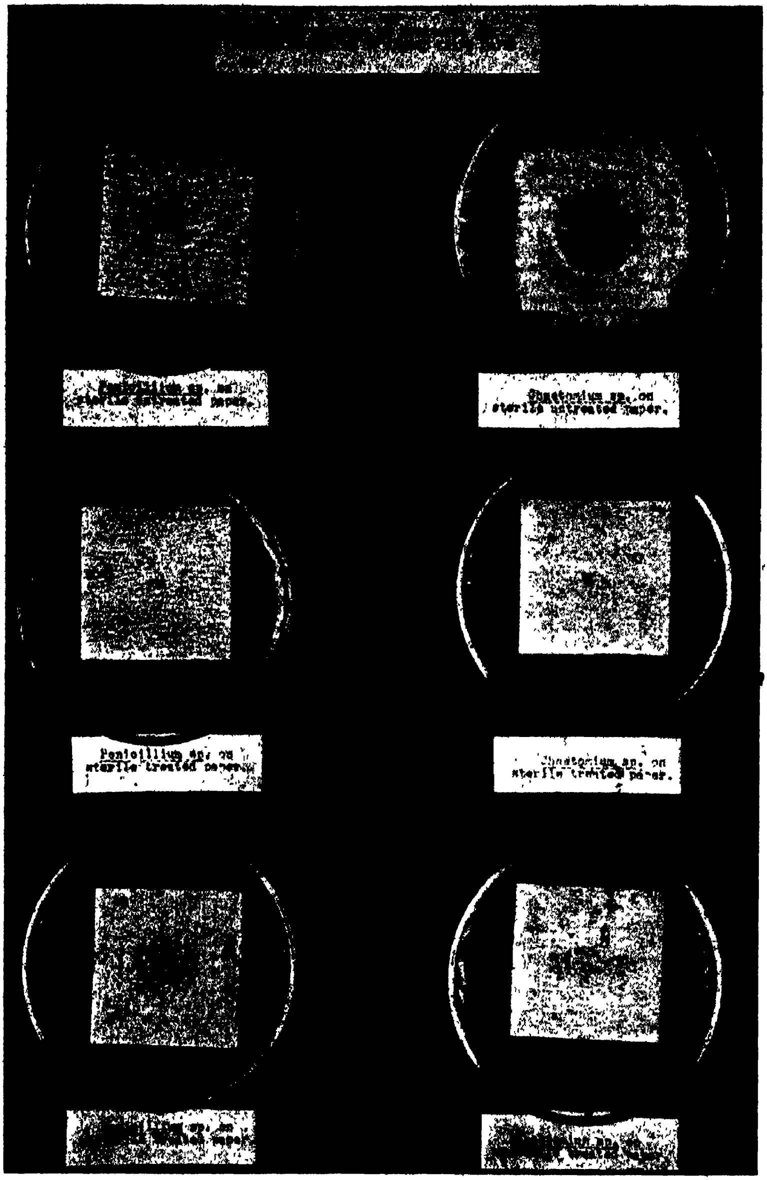

Penicillium sp. on sterile untreated paper.
Chaetomium sp. on sterile untreated paper.
Penicillium sp. on sterile treated paper.
Chaetomium sp. on sterile treated paper.

FIG. 7. Growth of *Penicillium* sp. (J674) and *Chaetomium* sp. (J647) on creped kraft paper, with and without Dowicide G.

Treatment of kraft paper with Dowicide G resulted in a product which effectively resisted fungus attack, even when incorporated into the paper in amounts as low as 0.7 per cent. Leaching of paper so treated resulted in a paper which supported some fungus growth; however, the fact that this inhibitor can be leached out should not be a deterrent factor in its use, since it is doubtful that much, if any, could be leached out when the paper is coated with asphalt.

Asphalt-coated case liner material prepared with treated paper and untreated asphalt was shown to be able to support fungus growth, so for complete mildew resistance it is necessary to incorporate an inhibitor in the asphalt as well as in the paper. Paper containing 1.6 per cent Dowicide G, infused with asphalt containing 3.0 per cent pentachlorophenol, was found to be completely mildew-resistant. Untreated paper infused with treated asphalt was found to be resistant to all of the test fungi except a species of *Trichoderma* (J646), so a reasonable degree of mildew resistance can be attained by adding inhibitor to the asphalt only. However, this method of treatment cannot be recommended unless the paper is very thoroughly infused with treated asphalt.

DEPT. OF BOTANY,
IOWA STATE COLLEGE
DEPT. OF BOTANY,
UNIVERSITY OF IOWA

SPECIES OF THE GENERA DOASSANSIA, DOASSANSIOPSIS, AND BURRILLIA IN INDIA

M. J. THIRUMALACHAR

(WITH 9 FIGURES)

Species of the genera *Doassansia* Cornu, *Doassansiopsis* (Setch.) Diet. and *Burrillia* Setchell are of extreme interest to workers on smuts on account of their rarity and the interesting types of life-cycles in many of the species. The rarity of these smuts is often due to the very obscure symptoms they produce on the host, which might range from an almost inconspicuous paling of the infected portions to definite discolored spots. In very few cases there is the formation of tumor-like excrescences on the host. In India, three species of *Doassansia* have been known by the determinations of Sydow and Butler. Another species, *Doassansia Hygrophilae* Thirumalachar, was added by the writer (1946). It is based on a collection of a leaf smut made near Nandi, Mysore, on *Hygrophila* sp.

No species of *Burrillia* was hitherto known to occur in India, and a first report of an undescribed species of *Burrillia*, viz. *B. Narasimhanii*, was made recently by Thirumalachar and Mundkur (1946) on *Alisma reniformis* G. Don. This has been followed up by the finding of another species of *Burrillia* on *Monochoria vaginalis* Presl. by the writer and it appears to be undescribed. The life-cycle of the smut has been worked out in some detail, and in this paper an account of it is presented. Some of the observations made on the other species of *Doassansia* and *Burrillia* are also included.

The genus *Doassansia* was founded by Cornu in 1883, with *D. Alismatis* (Nees) Cornu as the type. The sori are embedded in various parts of the host and are composed of hyaline to pale-yellow spore balls which are permanently embedded. There is usually a distinct layer of cortex surrounding the spore ball.

Setchell (1892), who studied the numerous species of *Doassansia* in considerable detail, recognized three subgenera of which *Doassansiopsis* was stipulated for those species in which the spore balls, instead of being filled by fertile spores, are made up of sterile pseudoparenchymatous cells. The fertile region is confined to a single outermost layer, and the entire spore ball is enclosed within a sterile cortex or hyphal sheath. The subgenus was raised to generic rank by Dietel (1897), but the genus is credited to Setchell by Liro (1938) and Ciferri (1938).

Doassansia Alismatis (Nees) Cornu. Ann. Nat. Sci. (Bot.) vi, xv, 269–296, 1883; Mundkur, Trans. Brit. Myc. Soc. xxiv, 312–336, 1940. On the leaves of *Alisma plantago* L. Achibal, Kashmir, 2–9–1908, leg. E. J. Butler.

Doassansia Hygrophilae Thirumalachar. Lloydia, 9: 24–30, 1946. On the leaves of *Hygrophila* sp.

Doassansia Hygrophilae is a leaf smut on *Hygrophila,* a member of the Acanthaceae. The spore balls are permanently embedded within the leaf tissue, presenting a punctate appearance on the surface. The spore balls possess a distinct sterile cortex and conform to the *Eudoassansia* type of Setchell. The mycelium and the young spores possess two nuclei, the mature spores having a single fusion nucleus. The spores have been germinated and have been found to develop a promycelium bearing a whorl of 6 to 7 sporidia which conjugate in pairs after they get loosened from the promycelium. The diploid mycelium formed after the conjugation of the sporidia has been found to develop secondary conidia in some cases.

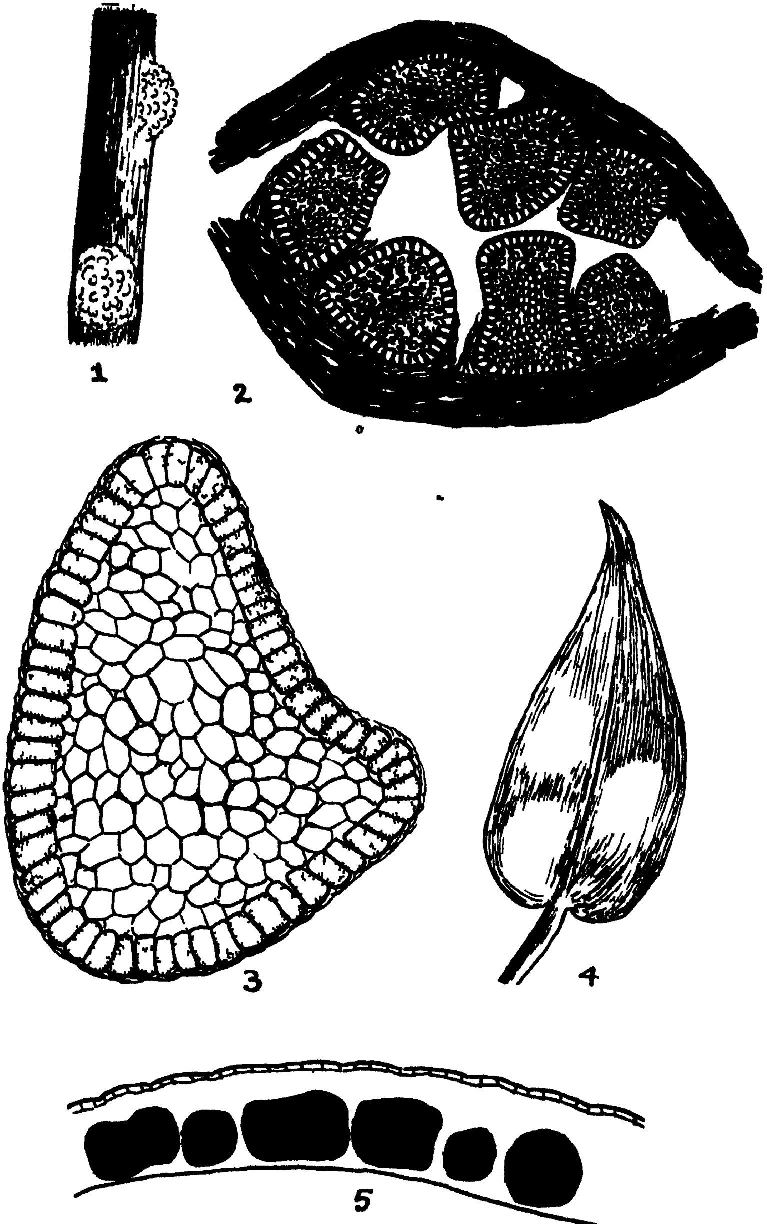
DOASSANSIOPSIS MARTIANOFFIANA (Thum.) Diet. Engler and Prantl's Die Natürlichen Pflanzenfamilien, 1**, 2–24, 1897. On floating leaves of *Potamogeton* sp., in Walur Lake, Kashmir, 17–9–1908, leg. E. J. Butler.

The smut is foliicolous forming circular orange-yellow spots, which gradually turn brownish-red. The spore balls are embedded within the mesophyll and in the early stages of development they appear to be applanate and compressed, surrounded by a thick felt of hyphal sheath. As the spore balls mature, a single fertile layer of spores is seen, surrounding a central core of sterile pseudoparenchymatous mass of cells. The sterile hyphal sheath also gradually becomes less conspicuous and later becomes evanescent. In mature spore ball its presence is indicated only by a delicate layer of hyphal cells which could be made out only with some difficulty. On the other hand, in the immature spore balls it is very conspicuously noticed and is composed of several layers. Clinton (1906) refers to this layer as merely a sterile cortex. Liro (1938) refers to these enveloping cells which are stated to measure 5 to 8 μ in diam. Dietel (1928) on the other hand differentiated between "Rindenzellen" which mean the cortical cells as distinct from the interlacing mass of hyphae surrounding the spore balls and states that the cortical layers are definitely absent in *D. Martianoffiana.* Ciferri (1938) also describes the outer sheath as being made up of lax interlaced hyphae and it seems desirable to identify such a layer as distinctly separate from the compact cortical layers found in many species of *Doassansia.*

Doassansiopsis Nymphaeae (Syd.) comb. nov. Petiolicolous, forming conspicuous tumor-like cushions, 5–16 mm. long. Spore balls compactly grouped within spaces formed in the tissue, densely clustered; angularly globoid to elliptical, 170–250 μ in diam., surrounded by a delicate layer of hyphae; spores ellipsoidal to prismatic, forming a single outermost layer, 12–16 × 7–11 μ, pale cinnamon brown, smooth, surrounding a central mass of sterile pseudoparenchymatous cells which are polygonal, thin-walled, measuring 10–25 μ.

On the leaves of *Nymphaea stellata* Willd., near Bassein, Bombay Presidency, 18-2-1912, leg. H. M. Chibber.

The smut was first collected by Chibber at Nirmal, Bassein and described by Sydow (1912) as *Doassansia Nymphaeae* Syd. and has so far not been reported from any other locality. A small fragment of the type became available for study, and some of the observations made by the writer proved the smut to be a species of *Doassansiopsis.* The smut produces hemispherical cushion-shaped galls on the petioles (FIG. 1). The spore balls are compactly grouped in clusters in lacunae formed within the hypertrophied tissue of the host, the margin of the cavity being lined with a felt of hyphae (FIG. 2). The spore balls are permanently embedded and do not show any tendency to get dislodged from their place. In carefully prepared sections of the spore balls, it was observed



FIGS 1–5

that the entire central mass of cells is composed of sterile pseudoparenchymatous cells. These do not possess any contents, and on crushing do not get separated as in the case of fertile spores. They are thin-walled, and of varying sizes, measuring 10–25 μ in diam. The fertile spores are grouped in a single layer and are ellipsoid to prismatic in shape. The cells are rich in contents and not vacuolate as in the sterile pseudoparenchymatous cells of the center. The spore ball on careful examination reveals a delicate layer of hyphae surrounding it.

All the above-mentioned characters clearly indicate that the smut is a species of *Doassansiopsis*. When an entire spore ball is examined under the microscope, the fertile spores in the margin of the field give the appearance of a sterile cortex and one is apt to mistake it for a species of *Doassansia*. Sydow, who considered the smut to be a species of *Doassansia,* describes a cortical layer which in fact refers to the fertile layer of spores. The spores are stated to be 8–11 μ in diameter and this corresponds with the breadth of the spores (7–11 μ) which in a polar view of the spore ball appear as rounded structures (FIG. 2). The pseudoparenchymatous cells in the center are actually much larger in size, measuring 10–25 μ in diam.

BURRILLIA NARASIMHANII Thirumalachar and Mundkur. *Papers in the Imp. Mycological Institute, Kew, England* (in press). On the leaves of *Alisma reniformis* G. Don., Donayakanapalya, Belur, Mysore, 26–9–1945, leg. M. J. Thirumalachar.

The genus *Burrillia* Setchell was established by Setchell (1891) for the accommodation of a smut on *Sagittaria variabilis* which was placed by Dietel as *Doassansiopsis pustulata* Diet. The genus is distinguished from *Doassansia* by the absence of any sterile cortex, but with or without the association of sterile parenchymatous cells in the spore ball. In the former case the spore balls would be associated with a few sterile cells which become distributed irregularly, and in the latter the entire spore ball is composed of fertile spores. With respect to the shape, structure and germination of the spores as far as they are known, there is close resemblance between *Burrillia* and *Doassansia.*

The smut causes pale yellow spots which in many cases are not distinctly observed. Sections through the region of the discolored spot reveal the spore balls within the mesophyll. The spores are not firmly united to form a compact ball, but are packed in crustose layers and thus resemble the spore balls of *Burrillia anomala* Crowell, described on a member of the Typhaceae in Canada (Crowell, 1940). The spores of *Burrillia Narasimhanii* have been germinated and it has been found that the sporidia do not conjugate in pairs after their formation, but begin to form secondary sporidia acrogenously.

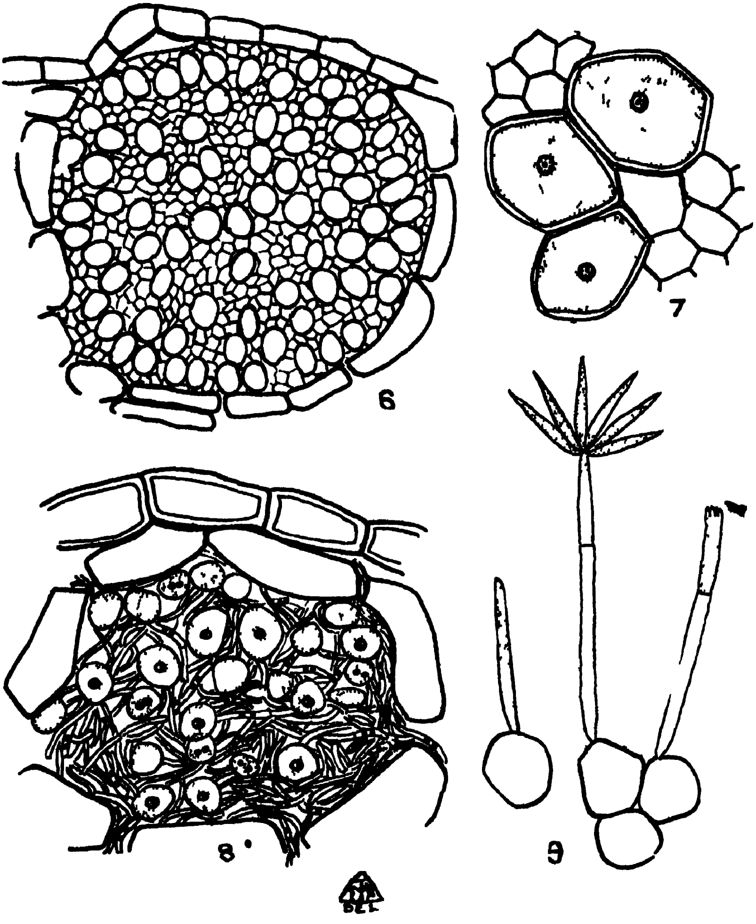
Burrillia Ajrekari Thirumalachar sp. nov. Sori in foliis efformantes maculas irregulares ad circulares, discoloratas, 3–15 mm. magnitud.; hae vero maculae sunt dispersae vel coalescentes, luteo-albae in inferiore facie, pallide violaceae in superiore facie. Sporarum globi infixi in mesophyllo, 120–197 × 114–306 μ, subgloboso ad rhomboidales, coalescentes inter se cum vicini sunt; sporae sparse distributae in sporarum globo, inter se unitae cellulis parenchymaticis tenuiter parietatis, pallide cinnamomo luteae, globosae ad sphaericas, tenuibus parietibus praeditae, magnitudinis 10–15 μ (medio 9.4). Sporae germinant in maturitate per 1–2-septatum promycelium quod producit 6-sporidia verticillata; haec vero statim bina conjugantur.

Hab. in foliis *Monochoriae vaginalis,* Bannerghatta, Bangalore, 23–6–1946, leg. M. J. Thirumalachar. Typus positus in Herb. Crypt. Ind. Orient. New Delhi, et in Herb. I. M. I., Kew, Anglia.

Sori in the leaves forming irregular to circular discolored spots of 3–15 mm. which are scattered or coalescent, yellowish-white on the lower surface and pale violet on the upper side. Spore balls embedded in the mesophyll 120–197 × 114–306 μ, subglobose to rhomboidal, coalescing with one another if in close proximity; spores sparsely distributed within the spore balls, joined together by thin-walled parenchymatous cells, pale cinnamon-yellow, globose to spherical, thin-walled, measuring 10–15 μ (mean 11.7 μ). Spores germinating at maturity by one- to two-septate promycelium bearing a whorl of six sporidia which conjugate in pairs immediately.

On the leaves of *Monochoria vaginalis* Presl., Bannerghatta, Bangalore, 23–6–1946, leg. M. J. Thirumalachar.

A leaf smut on *Monochoria vaginalis* growing in the marshy regions near Bannerghatta, a suburb of Bangalore, proved on a detailed examination to be a species of *Burrillia. Monochoria vaginalis* is a member of the Pontederiaceae, and Ciferri (1928) has described *Doassansia Eichorniae* Cif. on *Eichornia crassipes* from Santo Domingo. According to Zundel and Barnhart (1939), *D. Eichorniae* is the only smut known parasitizing a member of the Pontederiaceae. The *Burrillia* collected by the writer would therefore constitute a second smut species to parasitize a member of that family.



FIGS 6-9

The infection is very obscure, appearing in early stages by very slightly discolored patches on the lower surface. There is no indication or visible symptom of infection on the upper surface in the early stages. As the spore balls begin to be fully formed, the discoloration on the lower surface becomes more prominent and on the upper surface a greenish-violet tinge in the infected regions can be observed. The discolored patches on the lower surface measure 3–15 mm. in diam., and appear to coalesce with one another, forming a continuous patch (FIG. 4).

Sections through the leaf in the region of the infection patch reveal the presence of numerous spore balls embedded within the mesophyll tissue. These are mostly placed between the lower epidermis and the palisade layer, and measure 120–197 × 114–306 μ. They are subglobose to rhomboidal in shape and appear to coalesce with one another when in close proximity. The mycelium along the margin of the infection patch spreads and develops young spore balls in the mesophyll tissue, with the result that the mature spore balls are always situated towards the center and the younger ones along the periphery (FIG. 5). The spore balls which cannot be made out macroscopically on a fresh leaf appear in the dried leaf as small papillate pustules on the surface of the infection patch.

For cytological studies, the material was fixed in formalin acetic alcohol and microtome sections of 8 to 10 μ thickness were cut and stained with Newton's iodine gentian violet with light green as counterstain. For germinating the chlamydospores, the leaves bearing the sori were teased on the slides to release the spore balls. These were then germinated and stained by the method suggested by the writer (1940).

The mycelium within the host is visible before it gets grouped to form young spore balls. The mycelium leading up to the young spore balls is very fine and delicate, septate and distinctly binucleate. A large plectenchymatic mass is formed, two to four layers beneath the epidermal cells. The cells of the hyphae are closely intertwined with one another and as development proceeds, the zone of the hyphal cells becomes rounded up and possesses densely staining contents. The hyphal cells are binucleate and hence the young spores that are formed also possess the two nuclei (FIG. 8). The spores that are thus produced are very sparsely distrubuted within the spore ball and bound up by the remaining hyphal cells (FIG. 6). In later stages, these connecting hyphal cells also enlarge to some extent in size, lose their protoplasmic cell contents and become transformed into sterile parenchymatous cells. These cells are smaller than the spores in size and therefore can be clearly differentiated. In the mature spores (FIG. 7) there is a single fusion nucleus. The spores are ovate-ellipsoid to subspherical, pale cinnamon-yellow and measure 10–15 μ in diameter.

The spores were germinated and stained by the method already described. They require three to four days to germinate. The promycelium protrudes out by the rupture of the spore coat and the contents of the cell migrate into the germ tube thus formed. As in some of the species of *Doassansia* and *Burrillia* in which the germination stages are so far known, the promycelium becomes 1–2-septate, the septa separating off the empty portion of the promycelium. A whorl of 6 sporidia is produced at the apex (FIG. 9). The young sporidia are seen in early stages as small papillate projections and when excess of moisture is present, particularly in the case of submerged spores, the sporidia formed taper off into long whip-like structures which are slightly recurved. The further development of these sporidia which readily get detached from the promycelia is unknown. In those cases where the promycelium develops sporidia above the surface of water or without there being excess of moisture there is no tendency for them to elongate into whip-like branches, but instead they remain cylindric to fusoid, broader at the base than at the apex. Soon after their formation the sporidia begin to conjugate in pairs while still attached to the promycelium. The conjugation tubes are produced in the equatorial regions and by their fusion H-shaped pieces are produced. In *Burrillia pustulata* Setchell (1892) records a similar type of sporidial conjugation. On the other hand, in *B. Narasimhanii* the sporidia, soon after their formation, develop secondary sporidia acrogenously and have never been observed to conjugate with one another.

The present species of *Burrillia* differs in the structure of the spore balls and the measurements of the spores from any of the species so far known on other hosts, and the name *Burrillia Ajrekari,* in honor of Professor S. L. Ajrekar, is proposed.

UNIVERSITY OF WISCONSIN,
MADISON, WIS.

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EXPLANATION OF FIGURES

FIG. 1. Petiole of *Nymphaea stellata* with the tumors of *Doassansiopsis Nymphaeae*. Natural size.

FIG. 2. Spore balls clustered within the lacunae of the host. × 100.

FIG. 3. Spore ball of *D. Nymphaeae*. × 400.

FIG. 4. Leaf of *Monochoria vaginalis* with the infection patch. Natural size.

FIG. 5. Showing the position of the spore balls in the section of a leaf. × 80.

FIG. 6. Spore ball of *Burrillia Ajrekari* showing the sparsely distributed fertile spores within the spore ball. × 400.

FIG. 7. Mature spores showing the fusion nucleus. × 1800.

FIG. 8. Stages in the development of the spore ball. × 900.

FIG. 9. Germination of chlamydospores. × 900,

RHIZOPHYDIUM CHITINOPHILUM

Grace Antikajian [1]

(WITH 20 FIGURES)

In making routine collections of leaf mold, moist soil, and fresh water to be used as sources of chytrids for the mycology course at Columbia University, a new species of *Rhizophydium* was collected in Van Cortlandt Park, New York City, and isolated on strips of purified shrimp chitin.

All attempts to grow it on other substrata such as cellophane, bleached sections of young corn leaves, onion skin, hemp seed, hair, feathers, pollen of several species of angiosperms and of pine were unsuccessful. So far it has grown only on chitin or chitin agar as prepared by Karling (**1945**), and it differs in this respect from other known species of *Rhizophydium*. Morphologically this species is characterized by large, hyaline, spherical, oval, or pyriform sporangia, unusually coarse and extensive rhizoids, spherical zoospores containing a minute, hyaline, refractive globule and a larger, less refractive, granular body, and by smooth, brown, coarsely granular resting spores of various sizes and shapes. In this latter characteristic it differs specifically from other species of *Rhizophydium* which have been described in the literature. *Rhizophydium Closterii* Karling (**1946**), *R. Amoebae* Karling (*l.c.*), and *R. mycetophagum* Karling (*l.c.*) have brown resting spores like our species but the wall is either warty or the spores include one or more large refractive globules in contrast to the coarsely but evenly granular content of the species from Van Cortlandt Park.

In view of these structural characteristics and differences, this fungus is regarded as a new species and named *Rhizophydium chitinophilum* because of the type of substratum to which it is restricted.

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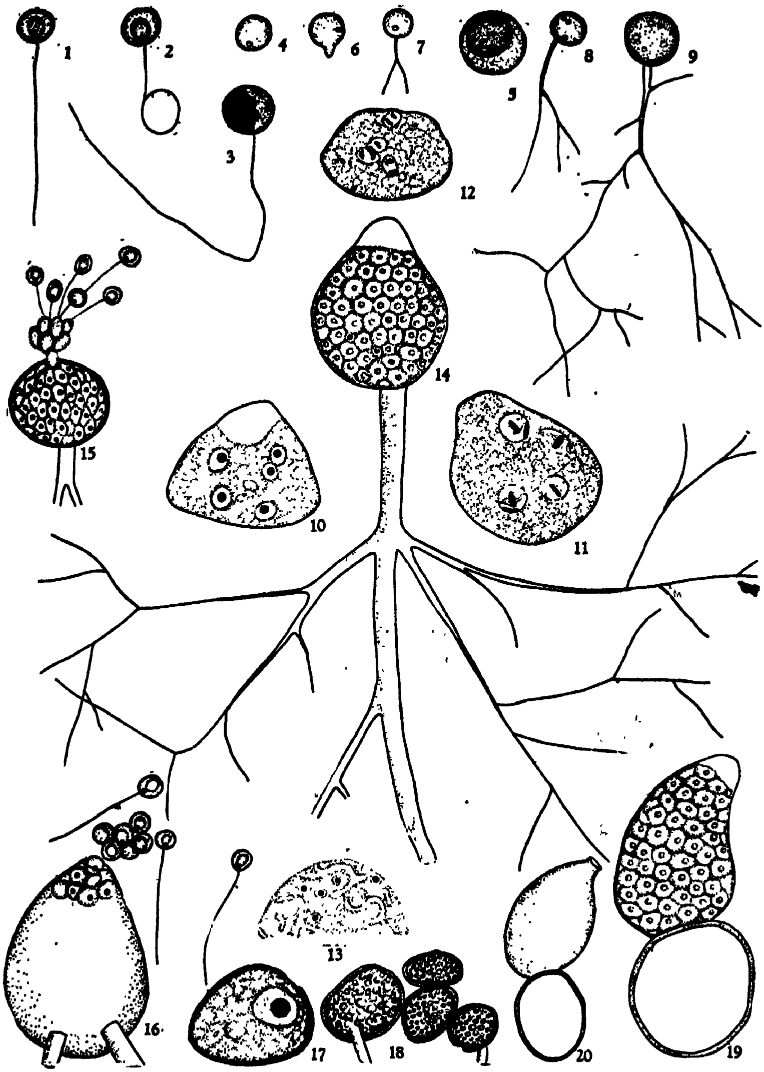
[1] The writer wishes to express her sincere appreciation to Professor J. S. Karling for his helpful advice during the course of this study.

Rhizophydium chitinophilum sp. nov. Fungus saprophyticus; sporangiis sessilibus, hyalinis, laevibus, sphaericis (7–69 µ), aut ovalibus (7–66 × 11–87 µ), aut pyriformibus (8–58 × 11–96 µ); 1–2 papillatis; zoosporis sphaericis (3.6 µ), flagello (21–26 µ) longo; sporis perdurantibus laevibus, fuscis, sphaericis (9–18 µ), aut ovalibus (7–14 × 9–17 µ), aut pyriformibus (7–11 × 11–14 µ), aut leviter irregularibus; prosporangiis germinantibus zoosporangia membranacea superficialia gerentibus.

Sporangia sessile, hyaline, smooth, spherical (7–69 µ), subspherical (15–66 × 17–74 µ), oval (7–66 × 11–87 µ), or pyriform (8–58 × 11–96 µ); neck of sporangium (4–17 × 11–28 µ); exit papillae one or two, low and broad, usually apical, filled with hyaline matrix (4–13 µ) high and (7–21 µ) wide. Zoospores spherical, approximately 3.6 µ with a minute refractive globule less than 0.7 µ and a large somewhat refractive, granular body about 2.2 µ; flagellum (21–26 µ). Rhizoids (2–16 µ) in diameter, richly branched, usually arising from a single point at the base of the sporangium, rarely from several points. Resting spores smooth, brown with coarsely granular contents; wall of resting spore 0.7 µ; on germination functioning as a prosporangium. Saprophytic on chitin, Van Cortlandt Park, New York City.

The life cycle and method of development of *R. chitinophilum* do not differ fundamentally from those of other species of *Rhizophydium,* so that it is not necessary to describe them in detail. Only the outstanding specific difference will be noted here. The zoospores which may remain motile up to half an hour are spherical (FIGS. 1, 2) with a long flagellum and a conspicuous refractive globule. Unlike most chytrid zoospores, however, no tail piece was found at the end of the flagellum when motile spores were fixed and stained by Couch's (1941) technique. In such spores a mass of deeply staining granules was persistently present (FIG. 3) which suggests the presence of a nuclear cap. The uninucleate (FIGS. 4, 5) zoospore germinates and forms a small penetration tube (FIG. 6) which by further growth and branching (FIGS. 7, 8, 9) eventually gives rise to the rhizoids, while the zoospore body enlarges and becomes the zoosporangium. The nucleus of the zoospore divides mitotically and simultaneously (FIGS. 11, 12) as the sporangium develops. After completion of mitosis and growth of the sporangium, the protoplasm cleaves progressively (FIG. 13) into uninucleate segments which become the definitive spores (FIG. 14). These ooze out in a globular mass at the time of dehiscence (FIG. 15) and disperse in the characteristic *Rhizophydium* manner (FIG. 16).



FIGS. 1–20.

The rhizoids usually arise at one point at the base of the sporangium, but in rare instances (FIG. 16) they may arise at two or several points. Like those of *R. macrosporum* Karling (1938) they may be unusually coarse (2–16 μ diameter), richly branched and extend for a distance of 115 μ (FIG. 14).

Resting spores of this species develop in great numbers on strips of chitin. They develop in the same manner as the zoosporangia up to a certain stage, and apparently remain uninucleate (FIG. 17) until germination begins. As noted in the diagnosis above, they are characterized chiefly by a smooth brown wall and, unlike most *Rhizophydium* species, have a coarsely and evenly granular content (FIG. 18). They germinate readily under laboratory conditions and give rise to a thin-walled, superficial zoosporangium (FIGS. 19, 20).

SUMMARY

Rhizophydium chitinophilum is a new chitinophilic chytrid which was isolated from soil from Van Cortlandt Park, New York, N. Y. This species is characterized by large, hyaline sporangia of spherical, oval, or pyriform shape, by spherical zoospores, and by smooth, brown, coarsely granular resting spores, and appears to be limited in occurrence to chitinous substrata.

DEPARTMENT OF BOTANY,
COLUMBIA UNIVERSITY,
NEW YORK, N. Y.

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EXPLANATION OF FIGURES

FIGS. 1–20. *Rhizophydium chitinophilum.* FIGS. 1, 2. Motile zoospores, × 1200. FIG. 3. Zoospore stained with Couch's technique, × 4000. FIG. 4. Zoospore which has lost its flagellum, × 1200. FIG. 5. Zoospore germinating on chitin. Stained section, × 4000. FIG. 6. Zoospore germinating in charcoal water, × 2120. FIG. 7. Zoospore germinating on chitin agar, × 1200. FIGS. 8, 9. Developmental stages of sporangia on chitin agar, × 1200. FIG. 10. Multinucleate sporangium, × 1600. FIG. 11. Sporangium with dividing nuclei in metaphase, × 1600. FIG. 12. Sporangia with dividing nuclei in anaphase, × 1600. FIG. 13. Portion of section of sporangium cleaving into segments, × 800. FIG. 14. Mature sporangium, × 73. FIG. 15. Sporangium beginning to discharge spores, × 166. FIG. 16. Sporangium in late stage of spore discharge, × 333. FIG. 17. Stained section of resting spore, × 1500. FIG. 18. Resting spores, × 1600. FIG. 19. Germinated resting spore with attached sporangium full of zoospores, × 1200. FIG. 20. Germinated resting spore with attached empty sporangium, × 1200.

TWO ADDITIONS TO THE FUNGI IMPERFECTI

Flora G. Pollack

(with 1 figure)

Two imperfect fungi which came to the writer's attention as interceptions by the Bureau of Entomology and Plant Quarantine, United States Department of Agriculture, proved to be new and are here described.

On February 8, 1946, plant quarantine inspectors intercepted in the cargo of an American steamer from China a portion of a dried tuber of *Colocasia esculenta.* Although the material appeared to be in a state of advanced desiccation, the fungus on it grew readily when transferred to corn-meal and malt agars. On corn meal it produced circular to irregular colonies which were white and cottony, with growth which was not heavy or dense. Within a week the fungus fruited abundantly over the surface of the colony, producing at length long chains of conidia which in mass were "dark greenish olive" to "olivaceous black." [1] Conidia size, shape, and color in culture were identical with that observed on the original specimen.

The fungus was tentatively determined as *Dendryphium* sp. An examination of the species of *Dendryphium* in the Mycological Collections of the Bureau of Plant Industry, Soils, and Agricultural Engineering revealed the presence of a culture of *Dendryphium* sp. determined by V. K. Charles and A. E. Jenkins in 1920 which had been isolated from dead cotton roots in Texas by J. J. Taubenhaus. This specimen is identical with the fungus on *Colocasia.* A third collection of the fungus was made in April, 1946, on Irish potato tuber intercepted from Mexico. This hyphomycete is here described as new.

Dendryphium obstipum sp. nov. Fig. 1, A and B

Mycelium byssoideum, subtile; hyphae 1.3 μ crassae, hyalinae; conidiophora hyalina, ad apicem subfusca, continua vel septata, 15–27 × 2.7–4.5 μ, sim-

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[1] Names of colors in quotation marks are according to Color Standards and Color Nomenclature, by Robert Ridgway (1912).

plicia vel e ramis adversis composita; conidia basipetalia, juvenilissima in apice conidiophori, conidia affixa restantia, in catenis longis, viridi-olivacea, 1–3 septata, typice 3, ad septa interdum constricta, obclavata, basi rotundato ex apice acuminato, interdum hilo distincto praedita, recta vel sub apicem obstipa, 15–19 × 4–7 μ.[2]

Mycelium cottony, fine, hyphae 1.3 μ wide, giving rise to conidiophores which are flask-shaped or elongate phialides 15–27 × 2.7–4.5 μ, and may arise as simple aerial branches which are lateral or terminal, or at other times branch profusely to form candelabra-like clusters with opposite branches, the apical cells of which function as phialides. They are hyaline or slightly dark at the conidia-producing tip and when young are filled with granular protoplasm. With age they become septate and eventually are completely emptied of their protoplasm content. Conidia are abstricted from the tips of the phialides in basipetal succession, conidia remaining attached to each other, forming long chains, many of 30 or more conidia. Conidia are subhyaline when immature, becoming greenish-olivaceous with age, 15–19 × 4–7 μ, 1–3 septate, typically 3, somewhat constricted at the septa, obclavate with rounded base and pointed apex, the apex sometimes showing a distinct hilum, straight or more usually with a bend (slight to about 90°) close to the apex, which is apparently the result of continued growth of the conidia after differentiation. The conidia being joined at both ends, the apical end to a more mature conidium and the basal end to a younger conidium or conidiophore, growth is possible only in a horizontal plane, resulting in a lateral extension of the conidia as seen by the growth to one side.

On dried tuber of *Colocasia esculenta* Schott (Araceae), China (San Francisco interception 20143), February 8, 1946. On dead roots of *Gossypium hirsutum* Linn. (Malvaceae), Texas, J. J. Taubenhaus, December 1920. On dried tuber of *Solanum tuberosum* Linn. (Solanaceae), Mexico (Brownsville interception 60867), April 13, 1946.

Culture on corn-meal agar from *Colocasia esculenta*. **Type** in Mycological Collections *71499*.[3]

The second fungus, a new species of *Bartalinia* on *Nolina microcarpa*, was intercepted at Nogales, Arizona, on May 26, 1945.

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[2] The writer wishes to acknowledge the help of Miss Edith K. Cash in the preparation of the Latin diagnoses in this article.

[3] The specimens cited in this paper have been deposited in the Mycological Collections of the U. S. Bureau of Plant Industry, Soils, and Agricultural Engineering, Beltsville, Md.

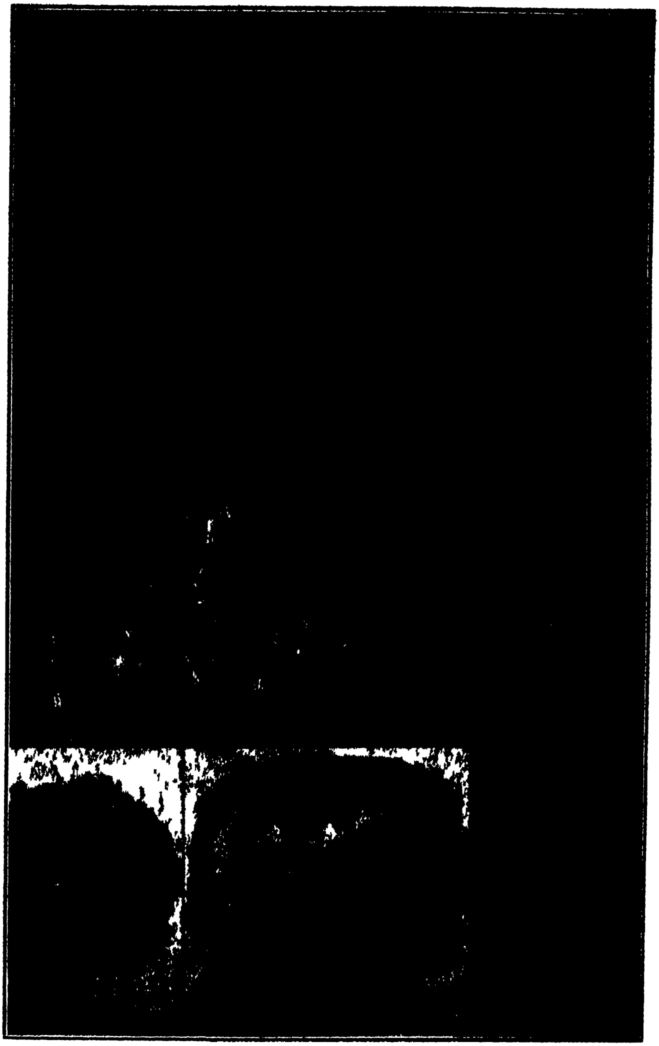

FIG 1, A and B. *Dendryphium obstipum* from culture. A, Conidiophores showing candelabra-like branching, × 1000. B, Chains of conidia, × 1000 C–E. *Bartalinia nolinae*. C, Top view of a pycnidium, showing ostiole, × 100. D, Cross-section through a pycnidium, × 100. E, Unstained conidia showing setae and inconspicuous basal mucous plug, × 570.

Bartalinia nolinae sp. nov. FIG. 1, C–E

Pycnidiis globosis vel subglobosis, usque ad 400 μ in diam., ostiolatis, subepidermalibus; conidiis clavatis, hyalinis, 2–3-septatis, rectis vel subcurvatis, 36–54 × 6.8–9.5 μ (setis et obturamento basali mucoso exclusis), apice setis tenuibus 2–7, plerumque 3–4, interdum ramosis, 6–24 μ longis, et obturamento basali mucoso 3–5 × 3 μ munitis; conidiophoris ellipsoideis usque subulatis, 6–15 × 2–4 μ.

Pycnidia formed in between the leaf veins, globose to subglobose, up to 400 μ in diameter, with a dark pseudoparenchymatous wall, 24–60 μ thick, ostiolate, innate, subepidermal, the pycnidia lifting out easily from the dried disintegrating tissue of the host. Conidia clavate, basal end rounded, somewhat narrower than the rounded to obtuse apical end, 2–3 septate (usually 3), not constricted at the septa, straight or slightly curved, hyaline, 36–54 × 6.8–9.5 μ (excluding setae and basal mucous plug). Setae arising from different positions on the upper surface of the apical cell, 2–7 (usually 3 or 4), delicate, sometimes branched, 6–24 μ long, and mucus-like plug at the basal end, inconspicuous, 3–5 × 3 μ. The setae, basal mucous plug, and spore wall do not take such stains as phloxine or cotton blue in lactophenol. Conidiophores short, ellipsoid to subulate, 6–15 × 2–4 μ, hyaline, occasionally adhering to conidia discharged from pycnidia.

On dead leaves of *Nolina microcarpa* S. Wats. (Liliaceae). Vicinity of Nogales, Arizona (Nogales interception 62345), May 26, 1945, P. R. Frink. **Type**, in Mycological Collections *71498*.

Saccardo set up *Pestalozzina* as a subgenus of *Pestalozzia* (now *Pestalotia*) with the note that it was identical with *Pestalozzia* except for the hyaline conidia. In recent years Guba (1), Wolf (3), and others have broadened the concept of *Pestalotia* so that it covers fungi of the *Pestalotia* type which produce conidia in either acervuli or pycnidia. No comparable study has been made of *Pestalozzina*. Although it seems probable that such a study might lead to a broadening of the genus, until it is made, only melanconiaceous fungi can be assigned to the genus *Pestalozzina*. The genus *Bartalinia* (2) which was set up for hyaline conidia of the *Pestalotia* type in pycnidia, will have to be retained for the time being.

UNITED STATES DEPARTMENT OF AGRICULTURE, AGRICULTURAL RESEARCH
ADMINISTRATION,
BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE,
WASHINGTON, D. C.

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NOTES ON THE GENUS ARMILLARIA

Alexander H. Smith [1] and Maurice B. Walters

(with 1 figure)

Armillaria decorosa (Pk.) comb. nov. (fig. 1)

Agaricus (*Tricholoma*) *decorosus* Peck, Bull. Buffalo Soc. Nat. Sci. 1: 42. 1873.
Tricholoma decorosum Saccardo, Syll. Fung. 5: 111. 1887.
Cortinellus decorosus Murrill, North Amer. Flora 10: 32. 1914.
Tricholomopsis decorosa Singer, Mycologia 35: 152. 1943.

This very rare agaric occurs in the vicinity of Cleveland, Ohio, where it is usually found limited to three or four fruiting bodies at the most. It appears rather late in the year, from October to mid-November. The exact dates on which it has been found during the past twelve years are November 16, 1935; October 14, 1938; October 19, 1941; and September 30, 1945. It has always been found growing on well-decayed and usually well-soaked logs of deciduous trees in a beech-maple-hemlock forest.

This species is perfectly illustrated in Icones Farlowianae, pl. 17, as *T. decorosum*, by specimens whose identity was confirmed by Peck himself. The Ohio material checks almost perfectly with the account in the Icones and so we have limited our comments here to a few on the fruiting bodies instead of giving a complete technical description. The pileus after expanding from the semiglobose shape of the young stage sometimes reached a diameter of 6 cm. It is cinnamon brown in color (Maerz & Paul 14–K–10), somewhat darker toward the center and thickly covered with long, fibrillose, erect scales of a darker color (blackish at tips). The margin of the pileus extends well beyond the gills. The gills are white, close, adnexed, broadest near the stipe, rather finely serrulate, and sometimes vertically costate. The stipe is sheathed up to the annulus with a coating similar in color and texture to that

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[1] Papers from the Department of Botany and the University of Michigan Herbarium.

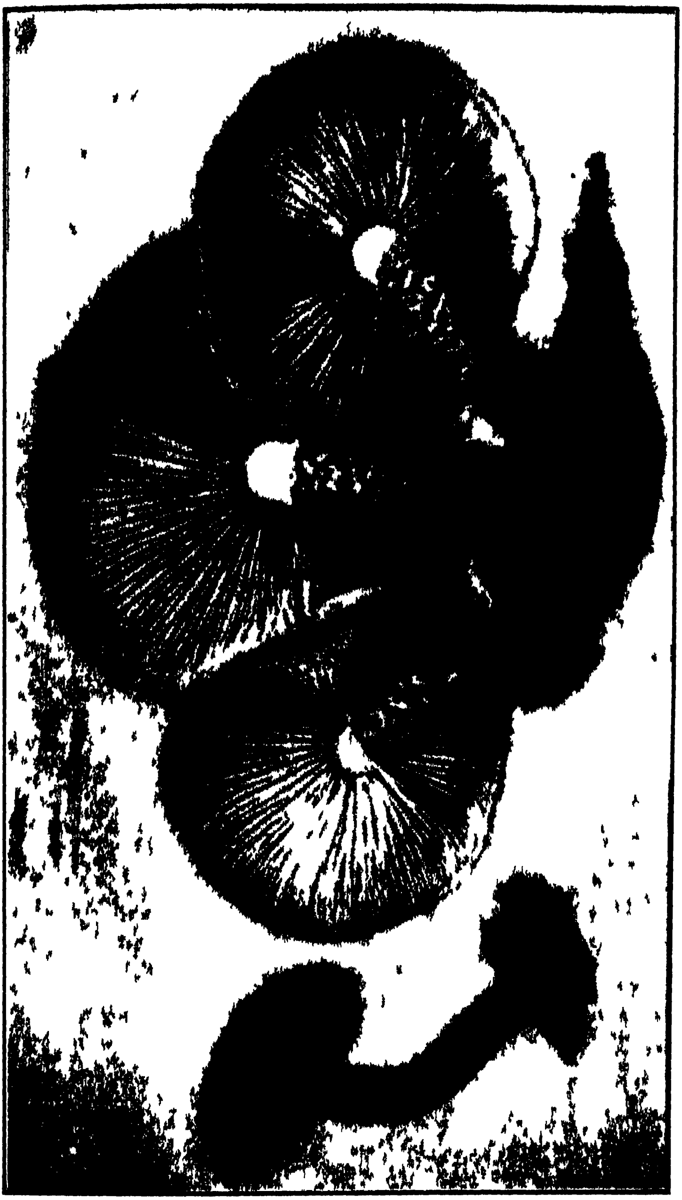


FIG 1 *Armillaria decorosa* ×1 Photo by M B W

of the pileus. It is smooth above the annulus, and usually tapers upward from a somewhat clavate base. The spores are smooth, elliptic, 6 × 4 μ, and amyloid.

Just why Peck considered this a *Tricholoma* rather than an *Armillaria* is not clear. In the Friesian system, which was the one followed by Peck, it would seem to be a much better *Armillaria*. It would certainly fall within the concept maintained by Kauffman (Pap. Mich. Acad. Sci. **2**: 53–67. 1923), since that concept is broader than that of Fries to the extent that the granulose species, which were placed in *Lepiota* in the Friesian system, were transferred to *Armillaria*. These granulose species have been recognized as a distinct genus and monographed under the name *Cystoderma* (Smith & Singer, Pap. Mich. Acad. Sci. **30**: 71–124. 1945). *Cystoderma* contains certain lignicolous agarics very similar in aspect and fundamental characters to *A. decorosa,* but differing in having the cap surface covered by sphaerocysts instead of true filaments. This one character is all that prevents *A. decorosa* from being classified as a *Cystoderma,* and seems to us to indicate a close relationship between the two genera. Singer (*l.c.*) transferred *A. decorosa* to his genus *Tricholomopsis.* He described the spores as non-amyloid. We tested the spores of the Ohio collections now preserved in the Univ. of Michigan Herbarium as well as one collection by Kauffman from the Adirondack Mountains in New York, and found them to be amyloid. Dr. Singer very kindly rechecked the material at the Farlow Herbarium for this character and reported that this time he obtained a weak amyloid reaction. On this basis the fungus should not be regarded as congeneric with *Tricholoma rutilans,* and hence we exclude it from *Tricholomopsis.* In our estimation it appears to be closely related to *Armillaria luteovirens,* the species proposed as the lectotype of the genus by Singer and Smith (Mycologia **38**: 259. 1946), both because of the presence of clamp connections and amyloid spores as well as the type of veil and the distribution of its remnants. Since in the closely related genus *Cystoderma* the habitat may be either lignicolous or terrestrial, that character cannot be given much emphasis here although it might be mentioned in passing that the lignicolous habitat is quite atypical as far as *Tricholoma* is concerned.

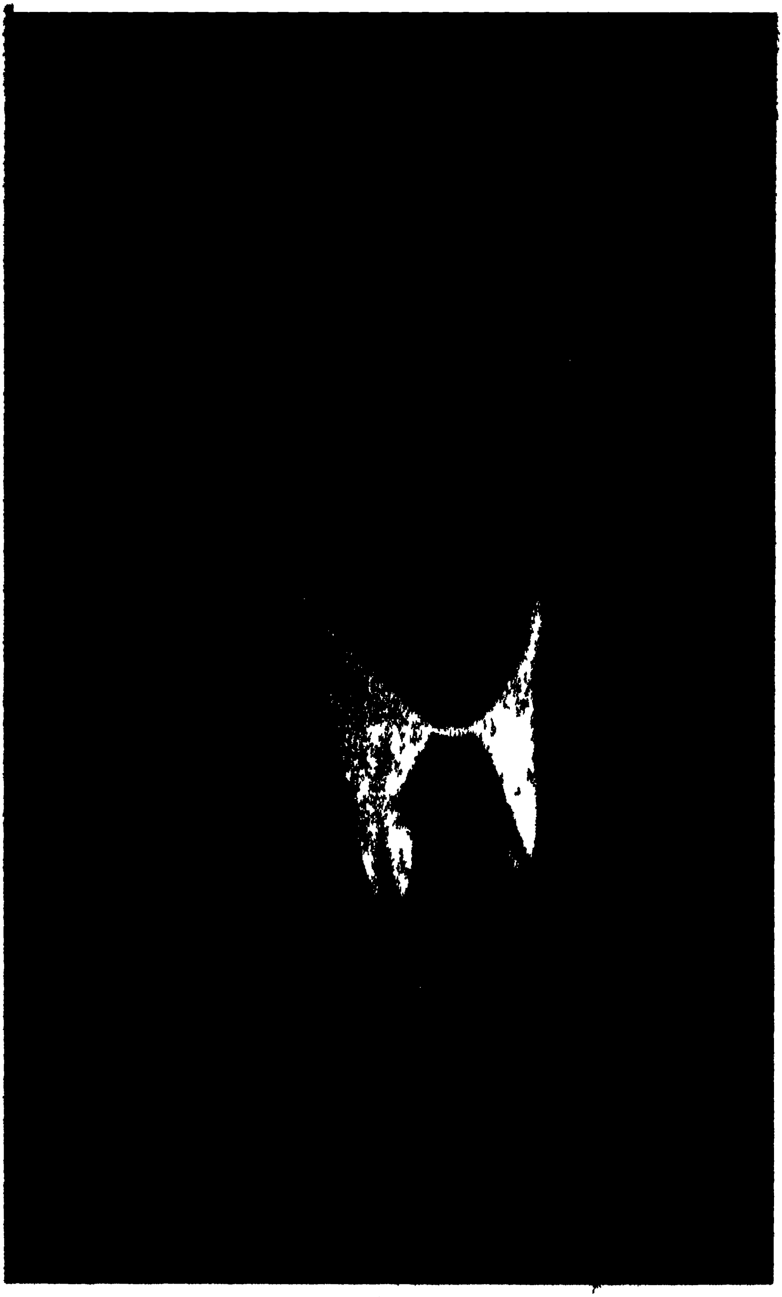
ARMILLARIA LUTEOVIRENS f. **alba** A. H. Smith f. nov.

Pileus 3–6 (8) cm. latus, albus, squamosus demum levis; lamellae albae, adnatae vel emarginatae; stipes 4–9 cm. longus, 5–10 mm. crassus, deorsum alba-squamosus, sursum glaber et albus; sporae 6.5–8 × 4–5 μ, amyloideae. Specimen typicum A. H. Smith n. ***20267;*** **in Herb. Univ. Michigan conservatum; legit prope Crown Point, Columbia Gorge, Ore., Oct. 30, 1944.**

Pileus 3–6 (8) cm. broad, obtusely conic to convex becoming broadly umbonate to plane, surface moist, at first innately squamose with long, flat scales which usually are recurved at the tip, more or less glabrescent in extreme age, dull white over all; flesh white, soft, thick in disc, odor and taste not distinctive; lamellae close, moderately broad, adnate becoming emarginate, edges even; stipe 4–9 cm. long, 5–7 mm. thick at apex, evenly enlarged downward, dull white throughout, with a superior submembranous annulus, silky and smooth above the ring, coarsely squamose below from innate, long, flat, recurved scales, somewhat glabrescent in age, spores 6.5–8 × 4–5 μ, ellipsoid to oblong, weakly amyloid, smooth; basidia four-spored; pleurocystidia and cheilocystidia none seen; gill trama parallel; pileus trama homogeneous or cells over surface somewhat collapsed and subgelatinous in age, clamp connections present.

This white form was found growing with typical specimens by Wm. B. Gruber in 1941; and by both Gruber and Smith in the same area again in 1944. This is apparently the first record of this species for North America.

UNIVERSITY OF MICHIGAN,
ANN ARBOR, MICHIGAN
AND
14556 SUPERIOR ROAD,
CLEVELAND HEIGHTS, OHIO



George B. Cummins, President 1946

MYCOLOGIA

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SOME PROBLEMS IN MYCOLOGICAL TAXONOMY *

GEORGE B. CUMMINS

Recently comments have been published concerning the status of taxonomy and the inadequacy of the financial support given to taxonomic research. Let us accept, as a generalization, that neither the status nor the support is ideal. One may then examine the condition of taxonomy and ascertain its points of virtue as well as its failures. Such an examination should enable us to direct our research toward improvement in the mycological taxonomy of the future.

Perhaps we should first employ the concept of systematic mycology. According to Swingle, systematic botany, and it applies to mycology, is that phase of botanical science which treats of the naming and classifying of plants. "Nomenclature deals with names, which may or may not indicate relationships. Taxonomy seeks to group plants on a basis of their similarities and differences, these being, as we now believe, expressions of actual phylogenetic relationships. We might conceivably have names without classification, but we can scarcely have classification without names." To all intents and purposes, then, nomenclature and taxonomy cannot be divorced and the problems of one affect those of the other.

Grouping according to relationships carries downward successively through the major categories to the least, the species, or,

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* Address of the President, 1946, Mycological Society of America, Boston, Massachusetts. Contribution from the Department of Botany and Plant Pathology of the Purdue University Agricultural Experiment Station.

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with present knowledge, to specialization within a species. Differences and similarities must be considered and weighed within species if species are to be based on morphology. The problems encountered at the species level may be as important and perplexing as those encountered at the generic level and probably cause more trouble in nomenclature. It is evident that an adequate classification can result only after the problems are solved for all categories.

A perfect classification is the desired end-product and continued effort should be directed toward that Utopian goal. But let us be both idealistic and practical, striving for a proper balance between the two. Irrespective of the pleasure which a taxonomist may derive from discovering a new species, splitting an established genus, seeking in the literature for the oldest valid name, or devising a system of genera or of families, he should not lose sight of the fact that his primary obligation is to be of service to his own branch of science and to allied sciences in need of his research product. Mycological taxonomy is not, and should not be looked upon as, an isolated science. If this branch of science is to reach or maintain its proper relationship to botanical science as a whole, or to mycology in the broad sense, the practical aspects of classification cannot be ignored. The serviceable products of taxonomic research are classifications which make it possible to gain a conception of the relationships of organisms, to permit reasonably ready identification, to give geographical distribution and host or substrate range, and to serve as a source of information concerning the important literature related to the organisms treated.

Mycological taxonomists cannot be accused of being non-productive, but we may be, in some degree, criticized for the lack of serviceability of our products. Too many of us have been more or less content to multiply the number of named species, genera, etc. We have probably been too zealous in seeking for and emphasizing differences in the fungi we study as opposed to finding and pointing out similarities. Although taxonomists have been accused of describing new, or supposedly new, entities for the pleasure of seeing their own names engraved in the archives of history, I question whether this is a particularly valid criticism. Unless his work is sound, anyone who persists in this practice soon finds that this engraved record is as likely to discredit as it is to credit his name. In the developmental stages of mycology it was necessary to name fungi and perhaps natural and desirable to emphasize differences, because classification is impossible without a fairly large and varied accumulation of named fungi. It may be argued that the present accumulation is still insufficient, but I doubt if many would support such an argument with respect to most groups of fungi. While continued naming and accumulation is necessary this is no longer the primary problem.

It can be argued with justification that a finished classification within any of the taxonomic categories is not now possible and will not be possible in the foreseeable future. This is not, however, a matter of major concern and certainly is no valid argument against accomplishing what is possible with the material and information now available. The need to bring more order into mycological classification as rapidly as possible is imperative.

There are few non-taxonomic workers whose research deals with fungi who do not deplore the time required to learn the identity and the previously published record of the fungus with which they are concerned. Being associated with plant pathologists I find that pathologists are primarily interested in pathological problems. The present status of taxonomic literature causes them to spend unproductive hours, insofar as their research is concerned, searching the literature for the identity, near relatives, geographical distribution, and reported host range of the parasitic fungi. It is safe to assume that this situation also prevails in other fields of science where fungi are encountered. Even those whose primary interest may be in the taxonomy of fungi are not exempt from similar expenditure of time that could otherwise be more productive. It is necesssary to exercise care or one becomes so involved in maintaining indexes of published records that actual taxonomic study suffers. The tail soon wags the dog.

One remedy for the present condition of systematic mycology is for taxonomists to divert their energies to and place major emphasis upon research that results in monographic treatments. Such research has many ramifications and cannot be completed overnight. On the other hand I believe it is a mistake to proceed on the assumption that insufficient information is available or to continue in that attitude of mind which leads to undue delay in publish-ing the available information. I do not mean to imply that such research is being ignored but rather that the need is great. We can afford to sacrifice some degree of perfection to meet this need more rapidly. Let us establish bases with our present accumulation of knowledge so that future taxonomic work may be both more rapid and more advanced.

In order to produce monographic treatments one must have access to adequate material, especially type specimens, and to the requisite literature. The availability of literature has been increased by the introduction of microfilm. The necessary specimens, including types where they exist, can usually be obtained by loan or exchange. This material is becoming concentrated in the larger herbaria. This, I believe, is desirable but places a considerable responsibility upon such institutions. If large and valuable collections are assembled by an institution they not only must be cared for but should be made available to qualified students. Unless adequate staff is provided this may mean that taxonomists associated with the institution become so involved in routine as to be non-productive in the midst of plenty. The deposition of duplicate type material in such herbaria is becoming standard practice. While it can probably not be made obligatory it would be a commendable practice to refrain from basing species on material which is too inadequate for at least limited distribution. The more troublesome problems revolve about poor descriptions accompanied by either poor or no illustrations and based upon material too inadequate to allow critical re-examination. Monographs are few that do not have a list of doubtful species appended.

The publication of monographs to bring the classification of the fungi up to date and to put it into serviceable form constitutes one of the major problems in mycological taxonomy. Excellent monographs have appeared recently but, considering the number of fungi and the need for such treatments, they are far too few.

Given the necessary specimens and literature the taxonomist should not be content merely to assemble keys, descriptions, and illustrations, although this has frequently been the practice and there is no denying that such works are useful. Real progress in taxonomy requires more than this and can result only when such publications are accompanied by an attempt to evaluate critically and interrelate the characteristics of the group treated. The individual assigns values to various features and these form the basis upon which he either aggregates or segregates the fungi under consideration. It may be that the individual has a clear conception of the relative phylogenetic significance of the characters which he employs but until the information upon which the concept is based is in print it profits no one but the individual in whose mind it resides. A regrettably large fund of such information goes to the grave annually and must again be accumulated by later workers.

An analysis of the characters used in the classification of the species of a genus or of the genera within a family adds greatly to the value of a classification and if a classification is sound, such an analysis is possible. The value of such analyses should be cumulative.

Here, I would emphasize again that similarities should be as diligently sought as differences. Is it not better to use six subgenera or sections for six closely intergrading groups of species than to segregate into six genera? To segregate emphasizes differences and increases the difficulty of identification, whereas to aggregate such intergrading groups emphasizes their obviously close relationship and increases the ease of identification. The result is a more serviceable and, I think, a taxonomically more sound classification. Questions of nomenclature may dictate the procedure to be followed. For example, *Uromyces* and *Puccinia* differ in only one character, the number of cells in the teliospore. There are numerous species where the spores are predominantly one-celled but because some two-celled spores occur the species is placed in *Puccinia*. There should be only one genus but to merge two large, long-established, and widely known genera would involve endless changes of names. Here we must yield to the practical, even though to do so may not be sound taxonomy.

The need for careful analysis and evaluation of the characters upon which classifications are based constitutes a second major problem in mycological taxonomy.

Many, one might say most, older and many modern descriptions are inadequate. This can be rectified only by critical restudy and redescription of type specimens or, where no type exists, of specimens which approximate authenticity. Such studies should have been made previously. The amount of the basic materials of taxonomy lost during the war is unknown but must be considerable. These losses do not decrease the need for such work; they rather emphasize the necessity to take appropriate action to prevent recurrence, whether from war, fire, or neglect, and to advance such restudy as rapidly as is possible.

Who would consider, as unnecessarily repetitious, a restudy, redescription, and accurate illustration of the many fungi described by Spegazzini, to cite only one example? I do not know what proportion of Spegazzini's types exists but the existing material is obtainable in most cases. Can we not instigate or encourage cooperative study leading to a more complete and a more rapid restudy of such basic materials? This would involve a planned interchange of specimens and should result in joint or at least co-ordinated publication. The field is large, of course, but planning should result in greater success than the occasional loan of a specimen. To refer again to the Spegazzini collections; I am confident that all of his critical rust species, for example, could be rather rapidly restudied in comparison with other American and probably African species if one cared to undertake such a task co-operatively with Argentine mycologists who have access to this material.

Types cannot continually be reworked without exhausting the material, which frequently is not abundant to begin with. Reexamination should be undertaken with the definite aim of putting into print detailed descriptions, adequate illustrations, and complete notes concerning probable relationships with other named material. Anything less than this will fail to meet the need.

Prior to the war many specimens of flowering plants were photographed in various herbaria of the world. Such photographs may not be equivalent to actual specimens but they are less destructible and can be readily reproduced and widely distributed. Mycologists would do well to attempt a similar program. In the course of my own research I have accumulated several hundred such photographs and other workers have done likewise. Exchange of specimens is a common practice; might we not distribute photographs with equal profit?

Closely related to the need of studying type material and working up monographs is the matter of geographical distribution. Taxonomic studies can no longer be considered adequate if limited to restricted areas. Fungi are probably more widely distributed naturally than has been generally realized. This applies both to saprophytes and parasites. In the case of fungi parasitic on economic plants or plants distributed by man, the possibility exists that the parasites may be distributed with the host materials and that both find conditions suitable for survival, or that the parasite is capable of attacking related but native hosts. Numerous examples could be cited. Some of them have proved costly to this country.

If synonyms are not to be further multiplied the taxonomist must become more thoroughly acquainted with the fungi of the world or, at least, of geographically similar regions.

Irrespective of one's particular like or dislike of delving into questions of nomenclature it is true that nomenclature is so intimately integrated with taxonomy that nomenclatural problems must be recognized and the necessary time and effort expended to find satisfactory solutions. The criticism has recently been voiced that nomenclature has not been stabilized because taxonomists have not seriously attempted to achieve stabilization. This criticism may have an element of truth but I doubt that one can infer that taxonomists have not desired stabilization. This is not the trouble. It appears to be, rather, that taxonomists do not agree concerning the best ways to achieve this goal.

Taxonomists set up their own rules, and there can be no objection to this. But having established rules, by majority opinion as voiced in Botanical Congresses, should we not abide by these rules, whether or not we agree, for such period as the rules remain in effect? Such conformity does not prevent anyone from assembling data in support of desirable changes. Until such time as he can convince the majority of the validity of his data, and the desirability of the change in rules which they necessitate, he should swallow his prejudice and conform to the existing rules. Americans, supposed exponents of majority rule, probably sin oftener than most. Consider the relatively minor requirement that descriptions be published in Latin. Do we wholeheartedly follow this requirement? Many do. Those who do not vary from outright refusal to those who meet the letter of the rule by providing a Latinized description so brief that it eliminates two lines of print that might otherwise be put to a useful purpose, but deliberately disregard the intent of the rule and the reasons upon which the rule is based. Or, consider the continual turmoil characteristic of the nomenclature of the rusts that has resulted from nonconformance with the International Rules.

This brief consideration of the problems in mycological taxonomy is by no means complete but has, I hope, touched upon the more urgent ones. To summarize, these problems are:

1. The preparation of monographic treatments of such scope and in such quantity as to place the classification of the fungi in both a sound and a serviceable condition.
2. The need to analyze and evaluate, with published supporting data, the significance of characters employed in the classification of fungi.
3. The critical restudy of the basic materials of taxonomy to obviate, insofar as is possible, the need for continued re-examination or the possibility of the destruction of this material.
4. The need to become adequately acquainted with the fungi of the world rather than with those of restricted areas.
5. The necessity to abide by the International Rules of Nomenclature as they now stand and/or as they may be revised.

The Arthur Herbarium,
Purdue University Agricultural Experiment Station,
Lafayette, Indiana

A SURVEY OF THE DISCOMYCETE FLORA OF THE OLYMPIC NATIONAL PARK AND ADJACENT AREAS[1]

BESSIE B. KANOUSE

(WITH 35 FIGURES)

This contribution is based upon the collections of Discomycetes obtained from the Olympic National Park by C. H. Kauffman on his two expeditions to the area, the first in 1915 to Lake Cushman and the second to Lake Quinault in 1925; and by Dr. Alexander H. Smith on three expeditions;[2] the first in 1935, the second in 1939 and the third in 1941. On all of these the collecting of Discomycetes was incidental. Primary emphasis was placed on the gill fungi. Although the cup fungi fruit most abundantly during the spring and summer seasons in this area, only one spring season, that of 1939, was spent by the above collectors in the region. Consequently no reliable data are yet available on the seasonal variation in the appearance of most species.

As can be seen by a glance at a map, the collecting has been carried out largely around the periphery of the Peninsula and at elevations varying from sea level to five thousand feet. During the spring of 1939 Smith collected in the higher regions of the Sol Duc River drainage as well as in the Boulder Creek drainage above Olympic Hot Springs. Several collecting trips to the higher elevations around Mount Angeles were also made. These stations are all located on the northern side of the Peninsula. The drier area which occupies the northeastern part of the Peninsula, the central mountain mass which occupies the interior, and the southern base of the Peninsula, as yet, remain unexplored as far as the Discomycete flora is concerned. The areas which have been most intensively studied are the river valleys of the western slope of the mountains from Lake Quinault to Cape Flattery and the northern side of the Peninsula, particularly in the vicinity of Lake Crescent and the mountains immediately to the south.

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[1] Papers from the University Herbarium, University of Michigan.

[2] Dr. Smith's expeditions were made possible by grants from the Horace H. Rackham School of Graduate Studies of the University of Michigan.

That the region contains a rich and varied Discomycete flora is evidenced by the following: from the 408 collections studied 173 species were identified. These represent seventy-four genera. Three new genera have been described previously: *Gelatinodiscus* and *Pseudocollema* by Kanouse and Smith (1940), and *Pseudociboria* Kanouse (1944). In addition, two new species, *Tryblidaria washingtonensis* and *Ciboria rufescens,* have been published (Kanouse, 1941).

The following species are here described as new. Two of these were not collected in the Olympic area, but will undoubtedly be found there. *Ascophanus brunneus; Belonioscypha minuta: Discina olympiana; Discinella washingtonensis; Humaria stellata; Humarina washingtonensis; Hyalopeziza Pteridis; Lachnaster miniatus; Ombrophila Lysichitonis; Phialea pallida; Phialea olympiana; Rutstroemia microspora.* Nine new combinations are made: *Humaria albocincta; Humaria coprinaria; Humaria crucipila; Humaria diplotricha; Humaria erinacea; Humaria melaloma; Humaria theleboloides; Ascophanus granulatus* var. *robustus; Chlorociboria aeruginascens; Phialea cyathoidea* var. *minutula; Dasyscypha capitata.* Two new names are given: *Ascophanus Velenovskýi; Lachnum bohemicum.*

The writer wishes to express her appreciation to Dr. A. H. Smith for his interest in this group and for collecting the specimens, also for his description of the area in which the work was carried out. Many thanks are due to Mr. Aurèle La Rocque for the preparation of the Latin diagnoses.

All collections have been deposited in the Herbarium of the University of Michigan.

All numbers cited are those of A. H. Smith unless otherwise stated. The identifications were made by the author unless a statement is made to the contrary. In addition to the reference to the publication of the name which is used, a second citation is sometimes given to a more complete or more accessible description, and for some species, a reference to an illustration is also given.

LIST OF SPECIES

ALEURIA AURANTIA (Fr.) Fuck. Symb. Myc. p. 325. 1869–1870; Seaver (1942, pl. 49).

This is a common species in the area. It is easily recognized by its bright orange color and by its reticulate-roughened spores. Seaver (1928) gives a good description and illustration.

On ground, Lake Ozette, Sept. 25, 1935, (*2602*); Cape Flattery, Oct. 1, 1935, (*2769*); Hoh River, June 30, 1939, (*14703*). Two collections, Lake Quinault, 1925, C. H. Kauffman and C. A. Brown.

ALEURINA ATROVINOSA (Cke.) Seaver. North American Cup-fungi, p. 101. 1928.

When fresh the apothecia measure 1–3 cm. in diameter and are colored "Prout's Brown"* to "Saccardo Umber." When dry the color is nearly black. The spores are sculptured.

Mt. Angeles, Sept. 21, 1941, (*17109*); Joyce, July 5, 1939, (*14788*).

APOSTEMIDIUM VIBRISSEOIDES (Pk.) Boud. Ann. Myc. 4: 240. 1906; Durand, p. 457. 1908.

The hymenium is pale gray to "deep olive buff" when fresh. The paraphyses which have colored tips distinguish this species from *A. guernisaci* (Cr.) Boud. According to Durand it is seldom collected.

On a wet stick, Lake Crescent, June 3, 1939, (*14020*).

ASCOBOLUS GEOPHILUS Seaver. Mycologia 8: 96. 1916.

The mucilaginous substance in which the spores are imbedded is bright yellow-green in color. The spores are marked with fine lines or ridges which form reticulations. As Seaver has pointed out, the number of spores in an ascus is frequently four instead of the usual eight. This collection extends the range to the western United States.

On earth, Elwha River, June 23, 1939, (*14599*).

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* Color names within quotation marks are taken from R. Ridgway, Color Standards and Color Nomenclature. 1912.

ASCOBOLUS GLABER (Pers.) Fr. Syst. Myc. 2: 164. 1823; Rehm, (1887–1896, p. 1121).

Apothecia substipitate, up to 1 mm. in diam., pale olive in color when fresh, smooth, margin somewhat ragged; asci 120–130 × 19–22 μ; spores 19–23 × 9–10 μ, purple brown, marked with longitudinal striations.

There is a wide variation in the sizes of asci and spores reported for this species. Seaver (l.c.) gives the asci as 300–350 × 40 μ and the spores as 23–38 × 12–13 μ. This exceeds the size found in our collections. The measurements given by Rehm (l.c.) and by Phillips (1887) are more like those reported here. It is, of course, impossible to know what the spore size was in the material Fries had when he accepted Persoon's species. Rehm's interpretation is followed here.

On cow dung, Elwha River, June 8, 1939, (*14186*); Hoh River, June 30, 1939, (*14704*).

ASCOBOLUS STERCORARIUS (Fr.) Schroet. Cohn's Krypt. Fl. Schles. 3 (2): 56. 1893; Seaver, p. 82. 1928.

A common species in the United States. On dung, Joyce, June 9, 1939, (*14223*).

ASCOPHANUS CERVARIUS (Phill.) Boud. Hist. et Class. des Discomycètés d'Europe. 1907. Originally described by Phillips (1879) as *Peziza cervarius.*

This species is distinguished in part by the brown color, by the asci which are abruptly attenuated at their apices, and by a negative reaction to iodine. The hyaline spores measure 15–17 × 7–9 μ. The paraphyses are hyaline, filiform, not enlarged at their apices, and are often branched above. As far as the writer can determine, this species has not been collected previously in the United States. Rea collected it in England.

On dung (woodchuck ?), Lake Crescent, May 27, 1939, (*13759*).

Ascophanus brunneus sp. nov. (FIGS. 1–3)

Apothecia solitaria, 0.5–1 cm. in diam., late sessilia, margine erecto, cinnamomea ad atro-brunnea; asci cylindracei, 225–250 × 16 μ, octospori; sporae

20–24 × 9–11 μ, ellipsoideae, hyalinae, leves; paraphyses filiformes, in maturitate confluentes et confusae.

Ad fimum, Lake Quinault, Washington, 4 Junii, 1939, No. *14062*, Typus.

Apothecia solitary, 0.5–1 cm. in diam., broadly attached, the margin up-raised, drying somewhat scalloped, externally cinnamon brown near the margin when fresh, becoming blackish brown downward, substance soft; hymenium dark brown to blackish brown (when dry), lighter at the margin; hypothecium prosenchymatic; asci cylindrical, 225–250 × 16 μ, the ascus tips becoming deep blue in iodine, 8-spored, spores uniseriate in the asci; spores 20–24 × 9–11 μ, ellipsoid, hyaline, smooth; paraphyses filiform, not enlarged upwards, 3 μ or less in width at the apices, colorless, clumps of paraphyses fusing and becoming indistinguishable in mature apothecia.

The large size of the apothecia and the dark brown color distinguish this species from others in this genus.

ASCOPHANUS GRANULATUS (Fr.) Speg. Mich. 1: 255. 1879.

On dung, Joyce, June 9, 1939, (*14221, 14842*).

A study of a number of collections from the Western United States has shown that two distinct fungi have been included under this name. In one of them the paraphyses measure 5–7 μ at the apices and are narrowly clavate. In the other they measure 14–18 μ and are subcapitate. C. A. Brown collected fungi with the narrow paraphyses at Lake Quinault, Washington, October 21, 1925. L. E. Wehmeyer collected the same at Mt. Hood, Oregon, October 4, 1922, and Snyder (1938) reported it from Washington under the name *Humarina granulata* (Bull. ex Fr.) Snyder. We also have an additional collection in the University of Michigan Herbarium from Tennessee (Underwood and Sharp No. *5406*). The spore size in all of these collections is 14–16(18) × 7–8(9) μ as reported by Snyder.

Rehm described a fungus in Ascomyceten Exsiccati No. *1357c* under the name *Humaria granulatus* (Bull.) Quél. In this collection the paraphyses measure 12–15 μ but Rehm reported them to be 8 μ. We have two collections made by A. H. Smith (Nos. *14221* and *14842*) in which the paraphyses are as broad as the asci which are about 18 μ in diameter. It is clear from the present study that these two units are distinct and that they represent good varieties. Starbäck (1898) was cognizant of a difference in the material that he had available for study and he proposed the name *robusta* for the unit with the large paraphyses. Seaver (l.c.) did not mention Starbäck's variety in his synonymy of *A. granulatus,* although he obviously had it instead of the typical variety. In view of this situation it appears that Starbäck's arrangement offers the most satisfactory solution of the problem, and is the one accepted here. Consequently the fungus with the slender paraphyses as described but not so distributed by Rehm is designated as variety *typica* and the epithet *robusta* is used in the sense in which Starbäck intended. However, since Starbäck described the variety under the genus *Humaria,* it becomes necessary to make a transfer to the genus *Ascophanus* and the combination **Ascophanus granulatus** var. **robustus** (Star.) comb. nov. is proposed.

Another point in regard to *A. granulatus* needs to be clarified. Velenovský (1934) described a species as *Ascophanus granulatus* but since his name represents a later homonym it is invalid. However, his species as described does not appear to be identical with any other in the genus and the name **Ascophanus Velenovskýi** nom. nov. is proposed for it.

Rehm stated that some American and English collections, including Ellis and Everhart North American Fungi No. *2039,* which the writer has examined, agree with the collections in Europe. He cited an illustration by Cooke (1879), as a good representation of the fungus. Cooke's figures show slender paraphyses which fact is at variance with Rehm's Ascomyceten No. *1357c.*

ASCOPHANUS OCHRACEUS (Cr.) Boud. Ann. Sci. Nat. Ser. V. **10**: 247. 1869; Seaver, p. 117. 1928.

On cow dung, Cape Flattery, May 27, 1939, (*13783*).

Belonioscypha miniata sp. nov. (FIGS. 4–6)

Apothecia gregaria, stipitata, 0.2–0.4 mm. in diam., plana, margine leviter involuto et rugoso granulis informis; stipes 50 µ altus, hypothecium pseudoprosenchymaticum; asci cylindraceo-clavati, 50–70 × 6–9 µ, octospori, sporae biseriatae in asco; sporae cylindraceo-fusoideae, subhyalinae, triseptatae, 10–12 × 2–3 µ; paraphyses filiformes, hyalinae, ultra ascum protrusae.

In caules vetustas caricis, Lake Tahkenitch, Oregon, 19 Novembris, 1935, No. *3552,* **Typus.**

Apothecia gregarious, stipitate, 0.2–0.4 mm. in diam., flat when moist with the margin slightly inrolled, delicately roughened by granules of an amorphous deposit outlining the cup, creamy yellow when fresh, drying pale yellow; stipe 50 µ in height; hypothecium pseudoprosenchymatic; asci cylindric-clavate, 50–70 × 6–9 µ, eight-spored, ascus pore becoming blue in iodine; spores usually biseriate, cylindric, with pointed ends, straight to slightly curved, subhyaline, three-septate, 10–12 × 2–3 µ; paraphyses filiform, hyaline, not enlarged at the apices, projecting slightly beyond the asci but not forming an epithecium.

The infected area of the leaf blade was outlined by an irregular darkened band which did not touch the fungus. It is not stroma-like, and it is not known how much importance its presence has in connection with the apothecia, but the two infected leaves that constitute the collection both show this character. Although so far known only from Oregon, this species is to be expected in the Olympic area in the vicinity of such lakes as Lake Ozette.

CENANGIUM FERRUGINOSUM Fr. Syst. Myc. 2: 187. 1823; Rehm, p. 227. 1889.

The spores measure 9–11 µ. The paraphyses are usually filiform but are infrequently branched above. Rehm (l.c.) gives a good description under the name *Cenangium Abietis* (Pers.) Fr.

On coniferous sticks, Mora, May 22, 1939, (*13676*).

Chlorociboria aeruginascens (Nyl.) Kanouse comb. nov. Not. Sällsk. F. Fl. Förh. X.

In making a revision of the genus *Chlorosplenium,* Seaver (1936) presents an acceptable solution concerning the limits of the genus. He retains *C. chlora* as the type of the monotypic genus. Under *Chlorociboria aeruginosum* he placed *C. aeruginascens* (Nyl.) Karst. in synonymy. The writer finds that there is a difference in the spore size of these two species and therefore considers them to be distinct. Rehm recognized the two species partly on the basis of spore difference. The spores of *C. aeruginascens* are 6–8 × 1.5–2 µ. In *C. aeruginosum* they measure 10–14 × 2.5–3.5 µ.

On *Alnus* sp., Boulder Lake, 4,500 ft. elev., May 28, 1939, (*13814*); on *Alnus* sp., Lake Quinault, June 2, 1939, (*13989*).

CIBORIA CAUCUS (Fr.) Fuck. Symb. Myc. p. 311. 1869–1870.

This species is the type of the genus *Ciboria*. The fruit bodies arise from black stromas on the *Alnus* fruits. Whetzel (**1945**) made the presence of a sclerotium a generic character and restricted the genus to those species that fruit on catkins and seeds. This is a more limited characterization of the genus than has been previously followed and it remains to be seen whether or not this concept will be found to be completely satisfactory.

On cones of *Alnus* sp., Lake Crescent, June 3, 1939, (*14026*).

CIBORIA RUFESCENS Kanouse. Mycologia **33**: 463. 1941.

This species is distinguished in part by the bright red coloring matter which is soluble in water. It grows on wet leaf packs.

Lake Quinault, May 17, 1939, (*13491, 13509*); on *Alnus* leaves, Spruce, Hoh River, May 19, 1939, (*13576, 13578, 13579*); Lower Hoh River, June 6, 1939, (*14149*); Lower Hoh River, June 30, 1939, (*14710*).

CIBORIA RUFOFUSCA (Weber) Sacc. Syll. Fung. **8**: 203. 1889.

Apothecia stipitate, up to 1.5 cm. in diameter, "Prout's brown" when fresh; stipe up to 1.5 cm. in length; asci 45–55 × 4–5 μ; spores 4–6 × 2–3 μ; paraphyses filiform.

On scales of cones of *Abies* sp., Boulder Lake, 4,500 ft. elevation, May 28, 1939, (*13808*); Deer Lake, June 13, 1939, (*14330*).

Probably this is the first instance of this species being found in the United States. In certain respects it complies with the specifications of the genus *Ciboria* according to Whetzel's definition; however there is no sign of sclerotia or stroma. Regardless of this fact the fungus seems best placed in *Ciboria* where Saccardo (l.c.) and Rehm (**1893**) included it.

CIBORIA TENUISTIPES Schroeter. Die Pilze Schlesiens 2 Hälfte —Krypt.-Fl. v. Schlesien, Dritter Band, p. 61, 1893–1908.

Apothecia stipitate, gregarious, arising from leaf blades or veins without stroma, 2 mm. in diameter, remaining expanded after drying, margin slightly scalloped, the free ends of the excipular cells forming a pubescence, hymenium dull brown, the outside of the cup mouse gray; stipe 3–10 mm. in height, expanding upwards into the cup; asci eight-spored, spores uniseriate in the asci, ascus pore not blue with iodine; spores hyaline, one-celled, 7–9 × 3–4 μ; paraphyses hyaline, filiform.

. On *Alnus* leaves, Forks, May 22, 1939, (*13671*).

CISTELLA DENTATA (Fr.) Quél. Ench. Fung. p. 319. 1886.

Apothecia scattered, pale watery gray, sessile, minute, frequently not over 300 μ in diam., excipular cells near the margin differentiated into hyphal extensions that are grouped together in fascicles making the margin appear dentate; asci short cylindric, 30–40 × 6 μ, ascus pore blue with iodine; spores 5–6 × 2.5 μ, biseriate in the asci, straight, one-celled, hyaline; paraphyses filiform.

On sticks of maple, Lower Hoh River, May 18, 1939, (*13538*). This is one of the old pre-Friesian species. It is a minute fungus, scarcely visible to the unaided eye when dry, yet it is fairly easily recognizable by means of the characteristic dentate margin of the apothecia together with the small size. Nannfeldt (**1932**) has proposed a good arrangement of a group of minute wood-inhabiting fungi which he puts in the family Hyaloscyphaceae. His treatment in this difficult group is the best known. The morphological characters upon which a classification must be based are largely those of the nature of the excipular hairs, marginal hairs and the type of paraphyses present. The genus *Cistella* is characterized by having small apothecia which are attached to the substratum by means of a small central attachment (not truly substipitate). The paraphyses are not lance-like, the hairs are thin-walled, septate, and arise from the excipular cells without being differentiated from the basal cell. The tips of the hairs are more or less club-shaped, often there are minute roughenings; marginal hairs are often arranged in broad teeth.

CISTELLA GEELMUYDENII Nannf. Studien über die Morphologie und Systematik der nicht-Lichenisierten Inoperculaten Discomyceten. p. *270*. 1932.

Apothecia gray-white, translucent, delicately fringed at the margin, minute, 0.1 mm. in diam., marginal hairs frequently arranged in tooth-like fascicles; asci 35–40 × 6–7 µ; spores 5–6 × 1.5–2 µ.

On wood debris, Hoh River, May 7, 1939, (*13219*).

CISTELLA XYLITA (Karst.) Nannf. (l.c.).

Nannfeldt has made a sharp distinction between species on the basis of substratum. He reports this one as limited to *Populus*. Our collection appears to be on *Alnus rubra*. It was found at Lake Ozette, May 15, 1939, (*13435*).

CLITHRIS GRAPHIS Rehm. Ann. Myc. 7: 533. 1909.

On fir, Lake Crescent, June 15, 1939, (*14391*); on pine, Crystal Ridge, June 17, 1939, (*14422*), and on fir, June 17, 1939, 4,800 ft. elev., (*14423*).

In the collection (*14422*) on pine the apothecia are heaped up in small piles instead of being sparingly scattered and graphis-like.

This species was described from specimens collected on "ramum corticatum balsamea" E. T. and S. A. Harper No. *2331* from San Juan Island, Washington. Our material agrees well with Rehm's description.

CLITHRIS JUNIPERI (Karst.) Rehm. Die Pilze Deutsch. Oester. u. der Schweiz. Lief. 29 (1888), in Rabenhorst Kryptogamen-Flora Bd. 1.

The apothecia are black and erumpent. The spores are one-celled and filiform. The paraphyses are flexuous and curled at their apices.

In Ascomyceten Exsiccati No. *272b*, Rehm described this species from *Juniperus nana*. This collection has been examined by the writer. Miss Cash reported this species from California, (Parks No. *5522*), on *Abies grandis*.

On coniferous twigs, Lake Crescent, June 15, 1939, (*14379*).

CUDONIA CIRCINANS Fr. Summa veg. Scand. p. 348. 1849.

Lake Crescent, Sept. 21, 1935, (*2535*); Boulder Creek, Oct. 5, 1935, (*3165*); Boulder Creek, Oct. 14, 1935, (*3136*); Boulder

Creek, Oct. 15, 1935, (*3164*); Forks, June 8, 1939, (*14435*); Joyce, June 9, 1939, (*14229*); Mt. Angeles, June 28, 1939, (*14677*); Joyce, July 5, 1939, (*13796*). Identifications were made by E. B. Mains.

CUDONIA GRISEA Mains. Am. Jour. Bot. 27: 322. 1940.

Hoh River, May 18, 1939, (*13521*); Olympic Hot Springs, June 5, 1939, (*14100*); on coniferous wood, Sol Duc Park Trail, June 19, 1939, (*14482*). Identifications were made by E. B. Mains.

CUDONIA MONTICOLA Mains. Am. Jour. Bot. 27: 322. 1940.

Cape Flattery, May 27, 1939, (*13785*); under fir, Lake Crescent, June 3, 1939, (*14009*); June 6, 1939, (*14060*). Identifications were made by E. B. Mains.

CYATHICULA ALPINA E. & E. Proc. Phil. Acad. Nat. Sci. p. 349. 1894.

This delicate fungus is stipitate with translucent, shining cups. The tooth-like fascicles of hairs at the margin measure 60–80 μ broad and 40 μ long. The asci are eight-spored; spores 6–9(10) × 1.5–2 μ; paraphyses filiform.

On *Equisetum* sp., Spruce, May 19, 1939, (*13584*); on stems, Boulder Lake, 4,500 ft. elev., May 28, 1939, (*13812*); on herbaceous stems (*Delphinium* sp.?), Sol Duc Park Trail, June 21, 1939, (*14485*).

CYATHICULA AQUILINA (Rehm) Sacc. Syll. Fung. 8: 307. 1889.

Apothecia sessile, translucent when fresh, changing to "chamois" when dry; marginal hairs in tooth-like fascicles, measuring up to 500 μ in length; spores 8–10 × 4 μ; paraphyses much branched.

On fern debris, Kalaloch, May 10, 1939, (*13302*); on *Gaultheria shallon* Pursh., Lake Crescent, June 2, 1939, (*13472*).

DASYSCYPHA AGASSIZII (B. & C.) Sacc. Syll. Fung. 8: 438. 1889.

On Douglas fir, Olympic Hot Springs, June 5, 1939, (*14098*); Deer Park, 5,100 ft. elev., June 16, 1939, (*14412*).

The traditional and probably the most acceptable description of the genus *Dasyscypha* is that published by Hahn and Ayers (1934). They review the interpretations of the genus that have been made and retain the name *Dasyscypha* for the *Lachnum*-like fungi with the filiform paraphyses in contrast to the genus *Lachnum* in which the paraphyses are lance-like. In general this is also the interpretation of the genus according to Rehm (1893). Nannfeldt (1932) would reduce the genus to synonymy with *Lachnum.*

Dasyscypha capitata (Pk.) comb. nov. (*Peziza capitata* Pk. 30th Rept. N. Y. State Mus. 1878.)

On old leaves, Lake Ozette, May 15, 1939, (*13424*).

The hairs are capped with large conspicuous stellate crystals. The spores measure 7.5–9 × 2 μ.

DASYSCYPHA ELEGANTULA (Karst.) Rehm, p. 852. 1896; Nannfeldt, p. 119. 1928.

Apothecia stipitate, covered thickly with long flexuous hairs, clove brown in color with hyaline tips; asci 90–100 × 10 μ, eight-spored; spores 13–15 × 3.5 μ, hyaline; paraphyses numerous, filiform, hyaline.

On *Delphinium* sp., 4,500 ft. elev., Boulder Lake Trail, May 28, 1939, (*13801*).

This interesting fungus has not been reported from the United States as far as can be determined. It has been found in Finland and Lapland (Karsten), from the Alps (Rehm), from Norway (Rostrup) and from Sweden (Lind). Nannfeldt (l.c.) gives its complete synonymy. The name *Dasyscypha fusco-brunnea* Rehm has been assigned to this species, but Nannfeldt places it in synonymy with *D. elegantula.* The spore measurements in the Washington collections are slightly larger than those given by Karsten and by Rehm, being 13–15 × 3.5 μ as compared with 6–15 × 2–

2.5 μ in Rehm's report. It is possible that the presence of the dark brown hairs together with the difference in spore size will be found to be important enough to justify re-establishing as a valid species *D. fusco-brunnea* which Rehm reported from the Atlas Mountains.

DASYSCYPHA PULVERULENTA (Lib.) Sacc. var. PURPURASCENS Rehm. Ann. Myc. **8**: 298. 1910.

The apothecia are small, bright canary yellow, and with patches of bright red extraneous material that cling to the hairs. On drying the red material (which may be resinous in nature) becomes tinged violet. The hairs are somewhat drawn together into bundles by the material adhering to them. The spores of this variety are slightly smaller than those reported for typical material. They measure 4–6 × 1.5 μ as compared with 5–8 × 1.5–2 μ in the typical variety.

On fir needles, Lake Crescent, June 2, 1939, (*13967*).

DESMAZIERELLA ACICOLA Lib. Ann. Sci. Nat. **17**: 83. 1829; Boudier, Icon. Mycol. **3**. 1905–1910. pl. 363.

The fungus is striking in appearance owing to the unusual paraphyses. They are branched above the middle, and the terminal portions are both pointed and dark brown. The exciple is sparsely covered with stellate hairs which measure 250–300 μ in length. The spores are smooth, hyaline, ellipsoid, and measure 15–18 × 10 μ. The asci are eight-spored. The species is rarely collected to judge from the infrequent reports in the literature. Boudier (l.c.) has an excellent illustration.

On needles of hemlock, Kalaloch, May 10, 1939, (*13305*).

DISCINA APICULATA (Cke.) Seaver. Mycologia **3**: 70. 1921.

Apothecia 2 cm. in diam., 2 cm. in depth, substance soft-watery, color of exciple "buffy brown," hymenium "olive brown" when fresh; spores ellipsoid, truncate with small flat apiculae, pale brown finally becoming minutely roughened; paraphyses colored at their apices.

On old cardboard carton, Hoh River, June 6, 1939, (*14153*); on an *Alnus* log, Hoh River, June 30, 1939, (*14723*).

These collections establish a record of this species for the United States. Seaver (1928) seems to cast doubt upon its occurrence in this country, but his description fits our western material very well.

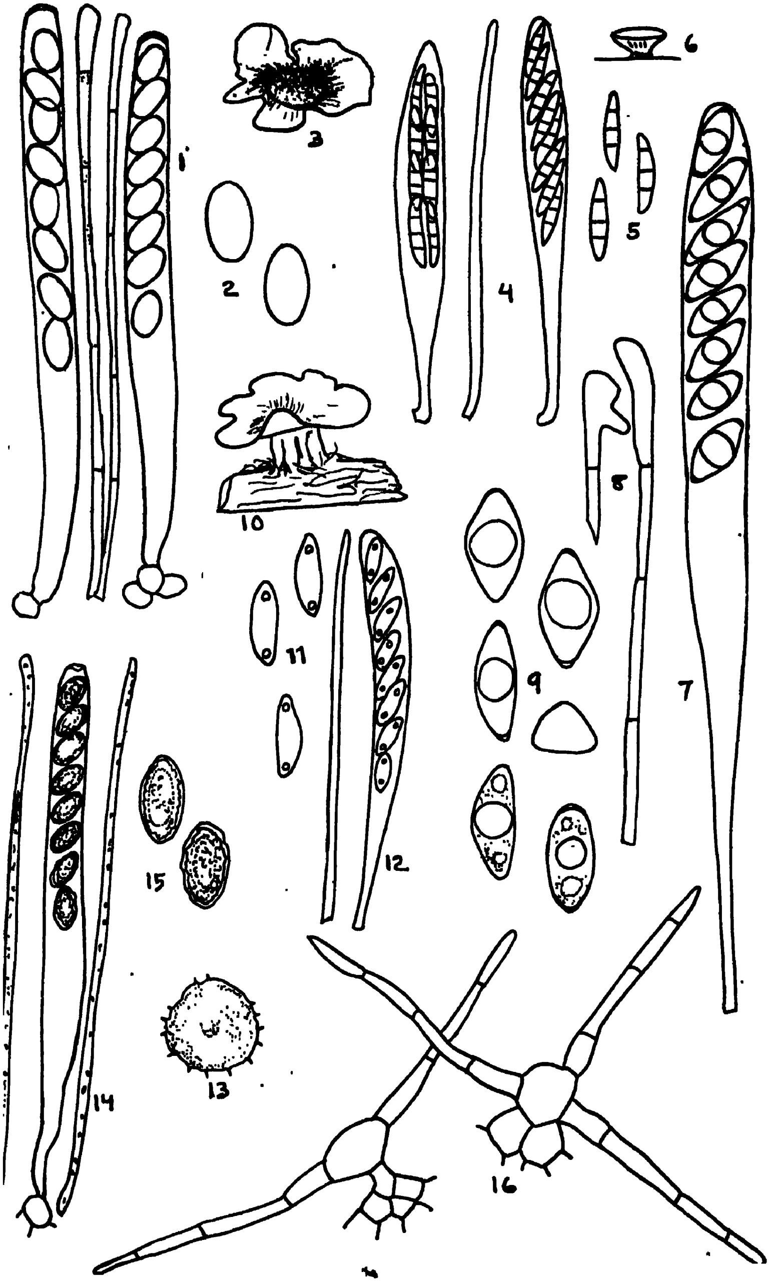
Discina olympiana sp. nov. (Figs. 7–9)

Apothecia dispersa, 1.5–3 cm. in diam., stipitata, substantia mollis crassaque, stipes 2–3 mm. latus, 2–3 mm. altus, rugosus in sicco, cremeus; hymenium luteolo-olivaceum, in sicco atrobrunneum, planum ad convexum, asci cylindracei, in caulem longum gracilemque acuens. Pars sporophora 275–300 × 20–22 μ, octospora, sporae uniseriatae; sporae subtrihedrales, ellipsoideae in uno aspectu, in altero late fusoideae, parietibus crassis, 30–32(36) × 12–14(16) μ, leves, saepe pileoloideis apiculis, uni- ad triguttulatae; paraphyses robustae, fasciculatae, brunneae, 7–9 μ.

Ad terram, Boulder Lake Trail, Olympic National Park, Washington, 28 Maii, 1939, Smith No. *13828*, **Typus.**

Apothecia scattered, 1.5–3 cm. in diam., stipitate, substance soft, thick; stipe 2–3 mm. in diam., 2–3 mm. high, wrinkled when dry, gradually expanded into the cup, cream to flesh-colored; hymenium "tawny olive" when fresh, drying blackish brown, flat with edge rolled under; hypothecium pseudoprosenchymatic; asci cylindric, tapering into a long slender stalk which readily collapses, the spore-bearing part 275–300 × 20–22 μ, eight-spored; spores uniseriate, asci not blue with iodine; spores subtrihedrate (like beech nuts), in one view truly ellipsoid, in another broadly fusoid to diamond-shaped, thick-walled, 30–32(36) × 12–14(16) μ, smooth, sometimes thickened at the ends to form small flat apiculae, containing one large highly refractive oil drop, frequently also containing two smaller oil drops; paraphyses stout, bunched together in fascicles, brown in color, 7–9 μ at their apices.

This fungus seems to be near *Discina perlata* Fr. but is a smaller plant and the spores are different. In *D. perlata* the spores are narrowly fusoid and are furnished with prominent apiculae, whereas in *D. olympiana* the spores are strongly three-sided. In one view they appear narrow and in another they are almost diamond shaped. This fact was ascertained by observing spores rotating in a water mount. The apiculae are inconspicuous in many of the spores. The outer wall of the spore appears to be of medium thickness and somewhat gelatinous. On drying the apiculae of the spores are more easily seen than when in a distended condition. The apiculae are not as easily observed on spores revived in KOH. Rehm re-



FIGS. 1–16.

marked that certain species of *Discina* lack the blue coloration in iodine. Boudier established the genus *Disciotis* for such species, but it does not seem to the writer to be a sound generic distinction.

Discinella washingtonensis sp. nov. (FIGS. 10–12)

Apothecia dispersa, brevistipitata, ex trama irregulare hyphis luteolis oriunda, hymenium planum ad convexum, 6–12 mm. in diam., hypothecium molle, crassum, parenchymaticum, pallide grisea, exsiccanda cinnamomea, centro olivascente; stipes 3–5 mm. altus, apothecio concolor; asci cylindracei, 80–90 × 8 µ. Octospori; sporae anguste fusoideae, symmetria variabiles, (11) 12–14 × 4 µ, unicellulae, hyalinae; paraphyses filiformes.

Ad ramulum arboris caducae, Forks, Washington, 22 Maii, Smith No. *13668*, **Typus.**

Apothecia scattered, 6–12 mm. in diam., short stipitate, arising from a weft of cottony yellowish hyphae, stipe short, expanding broadly upwards into the cup, 3–5 mm. in length, concolorous with the apothecia; hymenium flat, drying slightly umbilicate, dull watery-pallid gray when fresh, drying "cinnamon" with olivaceous tints at the center; hypothecium thick, soft, pseudoparenchymatic; asci cylindric, 80–90 × 8 µ, eight-spored, ascus pore becoming blue in iodine; spores narrowly fusoid, varying in symmetry, (11) 12–14 × 4 µ, one-celled, hyaline, smooth; paraphyses filiform.

The fungi in this genus resemble operculates but are in reality inoperculates. The apothecia are characterized by their dentate margin and their subtomentose exterior together with the small asci. *D. washingtonensis* approaches *D. Boudieri* in size of apothecia and spores but is distinguished from that species by the pale gray instead of the bay-purplish color. The habitat is also distinctly different. Boudier found his species on sandy soil whereas ours is a lignicolous fungus.

GEOPYXIS CUPULARIS (Fr.) Sacc. Syll. Fung. 8: 72. 1889; Seaver, p. 212. 1928.

On burned soil, Forks, May 31, 1939, (*13937, 13944*).

GEOPYXIS VULCANALIS (Pk.) Sacc. Syll. Fung. 8: 65. 1889. Seaver, p. 214. 1928.

On ground, Lake Quinault, Oct. 26, 1925, and Nov. 6, 1925, collected by C. A. Brown; Lake Quinault, May 17, 1939, (*13507*);

Graves Creek, May 23, 1939, (*13721*); Port Ludlow, May 30, 1939, (*13894*); Lake Crescent, June 3, 1939, (*13721, 14015*).

GELATINODISCUS FLAVIDA Kanouse and Smith. Mycologia **32**: 756. 1940.

Apothecia gelatinous, short stipitate, smooth; spores ellipsoid, smooth, subflavidous; paraphyses filiform, branched.

On *Chamaecyparis nootkatensis* Sudw., Sol Duc Park, June 20, 1939, (*14488*).

GODRONIA DAVIDSONI Cash. Mycologia **26**: 269. 1934.

Miss Cash described this species from specimens on *Ribes* from Colorado. Our collections are like hers in every respect.

On dead canes of *Rubus* sp., Lake Crescent, June 17, 1939, (*14342*).

GODRONIA URCEOLUS (Fr.) Karst. Rev. Mon. p. 144. 1891; Cash (l.c.).

On *Acer circinatus* Pursh., Lake Crescent, June 13, 1939, (*14345*).

HELOTIUM CARABORUM Vel. Mono. Discom. Bohem. Pars. 1. p. 208. 1934.

Apothecia minute, less than 1 mm. in diam., short stipitate, soft waxy, milky gray with a brownish margin; asci 60–90 × 6–8 μ, cylindric-clavate, eight-spored, spores obliquely uniseriate, ascus pore blue in iodine; spores one-celled, hyaline, 8–10(12) × 4–5 μ, ovate-elliptical, containing several oil drops; paraphyses filiform, slightly enlarged and brownish at the apices.

On moss, Lake Crescent, June 2, 1939, (*13979*).

In addition to several other species described on moss by Velenovský, the following have been reported also on that substratum by other authors: *H. bryogenum* Pk., *H. fuscobrunneum* Pat. & Gail., *H. turbinatum* (Fuck.) Boud.; *H. destructor* (Pk.) White. *H. caraborum* differs from all of these.

HELOTIUM CITRINUM Fr. Summa veg. Scand. p. 355. 1849; Rehm, p. 772. 1893.

On sticks, Lake Crescent, May 17, 1939, (*13508*); Hoh River, May 18, 1939, (*13527*); Lake Quinault, Oct. 22, 1925, collected by C. H. Kauffman and C. A. Brown.

HELOTIUM DESTRUCTOR (Pk.) White. Mycologia 34, p. 163. 1942.

On liverwort on a log, Kalaloch, April 23, 1939, (*12052*).

This species is frequent in northern Michigan. It is parasitic on liverworts and mosses and is easily spotted in the field by the dead patches which it produces. They are in sharp contrast to the green of the living plants adjacent to them. The apothecia are small, stipitate and colored "ochraceous buff" when fresh. This species has been reported as *Peziza subcarnea* Cke. & Pk., *Phialea subcarnea* (Cke. & Pk.) Sacc. and *Hymenoscypha subcarnea* (Cke. & Pk.) Kuntze. White's disposition of the fungus in the genus *Helotium* is the most acceptable.

HELOTIUM EPIPHYLLUM Fr. Summa. veg. Scand. p. 356. 1849; White, p. 139. 1943.

The apothecia arise in most cases from the veins of the leaves. No stroma is present. The color when fresh is "amber yellow."

On *Alnus* leaves, Lake Crescent, June 3, 1939, (*13932*).

HELOTIUM IMBERBE Fr. Summa veg. Scand. p. 356. 1849; Rehm, p. 775. 1893.

On *Alnus* bark, Lake Quinault, May 17, 1939, (*13493*); on sticks, Hoh River, May 23, 1939, (*13638, 13632*); on sticks, Graves Creek, May 23, 1939, (*13723*); on sticks, Clearwater River, May 24, 1939, (*13739*); on *Alnus* bark, Lake Crescent, June 3, 1939, (*14028*); on sticks, Elwha River, June 23, 1939, (*14593*).

HELOTIUM PHIALEA Fr. Summa veg. Scand. p. 355. 1849; Rehm, p. 784. 1893.

The color of the apothecia when fresh is "warm buff," but changes to bright buff-yellow when dry. The stipe measures 7 mm. in height. The plant is stout. Spore measurements are 14–16 × 7–8 µ. The spores finally become two-celled.

On leaves of *Sambucus callicarpa,* Elwha River, June 23, 1939, (*14396*).

HELOTIUM SCUTULA var. CAUDATUM Karst. Myc. Fenn. 1: 112. 1871.

When fresh the plant is white, but it turns pale yellow when dried except for the rolled edge of the apothecium which becomes dark tan. The stem is rather stout and firm and is thickened in the middle. The spores measure 18–20 × 4–6 µ. In contrast to the spores in the typical variety which are two-celled, these are one-celled. The ascus pore turns blue weakly in iodine.

On leaves of *Salix,* Lake Crescent, June 3, 1939, (*14030*).

HELOTIUM SCUTULA var. GROSSULARIAE Kauff. Papers Mich. Acad. Sci. Arts and Letters 1: 107. 1921.

This variety was described from material collected in Colorado on *Grossularia* sp. When fresh the color is avellaneous. The spores are smaller than in typical material. They measure 14–18 × 3.5–4 µ.

On herbaceous stems, Lower Hoh River, May 18, 1939, (*13533*).

HELOTIUM SCUTULA forma RUBI Rehm. Hedw. p. 229. 1885.

The one-celled spores measure (12)14–18 × 3–4 µ. They are slightly curved and are almost pointed at one end. Rehm described it from Europe. This appears to be the first report from North America.

On *Rubus* stems, Kalaloch, May 2, 1939, (*13076*).

HELVELLA CALIFORNICA Phill. Trans. Linn. Soc. Sci. II. 1: 423. 1880; Seaver, p. 250. 1928, 1942, pl. 70.

Represented by seven collections: Hoh River, May 7, 1939, (*13172*); Jackson Guard Station, May 13, 1939, (*13328*); Spruce, May 19, 1939, (*13557*); Hoh River, May 20, 1939, (*13643*);

Graves Creek, May 23, 1939, (*13719*); Elwha River, June 12, 1939, (*14286*); Hoh River, June 30, 1939, (*14720*).

The collection from Elwha River (*14286*) consisted of a fruiting body of unusually large size. It measured 16 cm. in width.

HELVELLA CRISPA Fr. Syst. Myc. 2: 14. 1823; Seaver, p. 247. 1928.

Olympic Hot Springs, Sept. 22, 1941, (*17185, 17192*); Mt. Angeles, Sept. 24, 1941, (*17216*); Chimacum, Oct. 13, 1941, (*17851*), collected by H. V. Smith.

HELVELLA ELASTICA Fr. Syst. Myc. 2: 21. 1823; Seaver, p. 249, pl. 40. 1928.

Lake Crescent, June 3 and June 5, 1939, (*14019, 14070, 14092*); Sol Duc Park Trail, June 20, 1939, (*14480*); Ennis Creek, June 25, 1939, (*14651*); Mt. Angeles, June 25 and June 28, (*14642, 14675*); Elwha River, July 3, 1939, (*14745*).

HELVELLA ESCULENTA Fr. Syst. Myc. 2: 16. 1823; Kanouse (1947 in press).

Hoh River, May 7, 1939, (*13171*); Boulder Lake Trail, May 28, 1939, (*13815*); Deer Lake, June 13, 1939, (*14307*); Deer Lake, June 24, 1939, (*14617*); Mt. Angeles, June 29, 1939, (*14672*).

HELVELLA INFULA Fr. Syst. Myc. 2: 17. 1823; Seaver, p. 251. 1928; Kanouse, 1947.

Lake Quinault, Oct. 3, 1925, collected and identified by C. H. Kauffman; Lake Quinault, Oct. 20, 1915, collected by Mr. and Mrs. Puttnam; Hurricane Ridge, Sept. 25, 1941, (*17279*).

HELVELLA LACUNOSA Fr. Syst. Myc. 2: 15. 1823; Seaver, p. 246. 1928. As *H. mitra,* Morse (1945); Kanouse (l.c.).

Olympic Mts., Oct. 19, 1915, collected and identified by C. H. Kauffman; Lake Crescent, Oct. 6, 1935, (*3013*); Olympic Hot Springs, Oct. 19, 1935, (*3259*); Joyce, Oct. 28, 1935, (*3383*);

Hoh River, June 30, 1939, (*14709*); Bremmerton, Feb. 1940, collected by J. B. Flett; Olympic Hot Springs, Sept. 22, 1941, (*17183, 17180*); Chimacum, Nov. 13, 1941, collected by H. V. Smith (A. H. Smith No. *17861*).

Humaria albocincta (B. & C.) comb. nov. (*Pezisa albocincta* B. & C. Grev. **3**: 154. 1875.)

This is a distinctive fungus characterized by the scarlet hymenium, very short hyaline hairs and by its growth on soil. The spores are rough.

On bare soil, Lake Quinault, May 21, 1939, (*13649*).

According to the International Rules of Nomenclature the name *Humaria* must be used for the species commonly relegated to the genus *Lachnea*. The names *Lachnea* and *Lachnaea* are invalid. The name *Patella* that Seaver selected to avoid the use of *Lachnea* is also untenable as it is pre-Friesian. The name *Humaria* is valid but must be used in the strict sense of Fuckel (1869–1870). It must not be confused with the name *Humaria* of Saccardo. As the latter author used the name it is a synonym of the genus *Humarina,* as Seaver (1928) has pointed out.

Humaria coprinaria (Cke.). comb. nov. (*Peziza coprinaria* Cke. Grev. **4**: 91. 1875.)

The following collections were found on dung: Whiskey Creek, June 22, 1939, (*14549*); Hoh River, June 30, 1939, (*14725*); Elwha River, July 3, 1939, (*14747*); Joyce, July 6, 1939, (*14843*); Hurricane Ridge, July 7, 1939, (*14861*).

Humaria crucipila (Cke. & Phill.) comb. nov. (*Peziza crucipila* Cke. & Phill., Cooke, Mycographia, p. 136. 1876.)

The presence of the peculiar compound star-shaped hairs is the character by which this species is recognized. The color when fresh is pale ocher yellow. Seaver (1928) gives a good description under the name *Patella crucipila.*

On sticks, Lower Hoh River, May 18, 1939, (*13547*).

Humaria diplotricha (Rehm) comb. nov.

This fungus was described by Rehm (1904) as *Lachnea diplotricha* from material found on bare soil, in Ohio by C. A. Lloyd (Lloyd No. *02687*). Seaver (1928) placed it in synonymy with *Patella theleboloides* (A. & S.) Seaver. It seems to be distinct from *P. theleboloides,* however, on the basis of substratum, difference in spore size and a difference in color. Seaver (1928) reports the spores of *P. theleboloides* as 14–20 × 7–10 µ. Rehm gives the spores of *L. diplotricha* as 14–15 × 7–7.5 µ. Those in our western collections measure 14–16 × 8–9 µ which is more nearly like those in *L. diplotricha.* The color of the apothecia in our plants and *L. diplotricha* is some shade of orange rather than yellow. Our specimens, like those found in Ohio, were on bare soil rather than on dung.

On bare soil, Elwha River, June 3, 1939, (*14749*).

Humaria erinacea (Schw.) comb. nov. (*Pezisa erinacea* Pers. ex Fr. Syst. Myc. **2**: 86. 1823.)

On wood of *Populus trichocarpa,* Lake Quinault, May 17, 1939, (*13510*).

Humaria Lusatiae (Cke.) comb. nov. (*Pezisa Lusatiae* Cke. Monographia, p. 80. 1875.)

On cotton wood, Hoh River, June 6, 1939, (*14158*).

Humaria melaloma (Fr.) comb. nov. (*Pezisa melaloma* Fr. Syst. Myc. **2**: 68. 1823.)

The distinguishing feature about this species is the presence of adpressed hairs on the outside of the apothecia. The hairs are septate and arise from large spherical, brown-walled cells. The spores in our collection measure (12)14–15 × 7–9 µ. They are smooth. The paraphyses are very slender and are not enlarged at their apices. They extend beyond the asci for a considerable distance.

On soil, Elwha River, July 7, 1939, (*14748*).

HUMARIA SCUTELLATA (L.) Fuck. Symb. Myc. p. 321. 1869–1870.

On decaying *Alnus* log, Graves Creek, May 23, 1939, (*13727*); on soil, Port Ludlow, May 30, 1939, (*13697*).

HUMARIA SETOSA Fuck. Symb. Myc. p. 321. 1869–1870.

On debris in mud, Lake Quinault, May 17, 1939, (*13406*); on *Alnus* log, Elwha River, July 4, 1939, (*14760*).

Humaria stellata sp. nov. (FIGS. 13–16)

Apothecia solitaria ad caespitosa, 2–3 mm. in diam., sessilia, plana ad convexa, irregularia cum stipata sunt, extus setis stellatis 70–100 × 12–20 μ sparse obtecta, eis plerumque bis ad quater furcatis, ex cellula tumida oriunda, pallide brunneis, parietibus crassis, septatis, apicibus obtusis; hymenium aurantiacum ad rubrum exsiccando fuscior; asci cylindracei, 200–225 × 10–12 μ, octospori; sporae uniseriatae, ellipsoideae, 16 × 10–12 μ, endospora crasse verrucosa, exospora tenuis, levis, in sicco rugulosa; paraphyses plurimae, filiformes.

Ad terram, Shuksan Inn, Washington, 14 Augusti, 1941; Smith No. *16162*, **Typus.**

Apothecia solitary to caespitose, 2–3 mm. in diam., sessile, flat to convex, irregularly cup-shaped when crowded, externally sparsely covered with stellate hairs, hairs 70–100 × 12–20 μ, usually from two to four arising from a swollen subspherical cell, hairs and basal cell with brown walls, hairs septate, blunt-tipped, the stellate hairs so arranged that the outer surface of the cup appears as if covered with an irregular, large-meshed net, the simple hairs also short; hymenium orange to red when fresh, orange when dry, pale creamy yellow when revived in water; asci cylindric, 200–225 × 10–12 μ, eight-spored, iodine not coloring the ascus; spores uniseriate, ellipsoid, 16 × 10–12 μ, hyaline, one-celled; the exospore thin, becoming somewhat wrinkled; endospore roughened with prominent warts; paraphyses numerous, filiform, hyaline, non-septate, scarcely widening at the apices and measuring 5 μ in diam.

There are only a few species described with stellate hairs. These are *Patella stercorea, P. curvipila, Lachnea alpina,* and *L. umbrorum.* With the exception of *L. umbrorum,* all have smooth spores. The hairs of *H. stellata* are sparse, and are composed of from two to five (usually two to three) radiating spines which arise from a central swollen cell. The hairs, as well as the cells, are colored light brown, are short and stout, and are adpressed to the apothecia. A very few simple hairs are found scattered over the surface of the apothecia. The spores in *L. umbrorum* are rough and the measurements 23–24 × 12–14 μ are considerably greater than those in *H. stellata*. The small warty spores, together with the stellate hairs, are diagnostic for our species. The detail of the spore wall was studied with an oil immersion lens. It could not be clearly seen otherwise that the roughness was on the inner wall of the spore. An examination was made of the fresh spores of *Discina perlata* which also are roughened and are provided with apiculae. The roughening in this species also was found to be on the endospore wall. The outer wall is considerably thicker than in *H. stellata*. When spores of both species were mounted in a two per cent solution of KOH the apiculae and the wrinkled outer wall became smooth. The roughening is probably due to the drying down of the exospore over the warts on the endospore. This is an observation that may be found to throw light on the structure of roughened spore walls in species other than the two here mentioned.

HUMARIA STERCOREA (Pers. ex Fr.) Fuck. Symb. Myc. p. 321. 1869–1870; Seaver (1928 as *Patella stercorea*).

On cow dung, Queet's River. May 3, 1939, (*13093*).

Humaria theleboloides (Fr.) comb. nov. (*Peziza theleboloides* Syst. Myc. **2**: 88. 1823.)

The marginal hairs are scarce, as few as 14 were counted on some apothecia. The spores measure 18–20 × 10–14 μ and are without oil drops. The paraphyses are clavate-tipped.

Crescent Beach, Oct. 3, 1935, (*2851*); on cow dung, Crescent Beach, June 21, 1939, (*14509*); on dung of wild cattle, Hurricane Ridge, July 7, 1939, (*14862*).

HUMARINA OCHROLEUCA (Clem.) Seaver. North American Cup-fungi, p. 131. 1928.

On soil, Joyce, Sept. 24, 1935; (*2591*).

Humarina washingtonensis sp. nov. (FIGS. 17–19)

Apothecia gregaria ad stipata, in humo semi-infixa vel sessilia, pallide aurantia, in sicco pallidiora, concoloria, mollia, cerea, glabra, excipulum rugulosum, margo crenatus, in sicco vadose cupuliformis; hypothecium crassum, pseudoprosenchymaticum, cellulae magnae parietibus tenuibus; asci cylindracei, pedicellati, 175–200 × 9–10 µ; sporae leves, hyalinae vel subhyalinae, anguste ellipsoideae (14) 16–18 × 7–9 (10) µ, uni- vel biguttulatae; paraphyses filiformes, apice 6 µ, flavidulae.

Ad terram et ramulos deustos, Heart O' Hills, Washington, 25 Junii, 1939, Smith No. *14654*, **Typus.**

Apothecia gregarious to crowded, sessile, frequently partly embedded in the ground, "apricot buff" to "apricot orange" when fresh, paler when dry, concolorous throughout, soft, waxy, exciple faintly creased with ridges which extend downwards from the dentations on the margin of the cup, glabrous, remaining shallow cup-shaped on drying; hypothecium thick pseudoprosenchymatic, cells large, thin-walled; asci long cylindric, long pedicellate, the pedicel easily collapsing, 175–200 × 9–10 µ, eight-spored; spores smooth, one-celled, narrowly ellipsoid, (14) 16–18 × 7–9 (10) µ, containing one to two highly refractive guttulae, hyaline to subhyaline; paraphyses filiform, apices clavate, reaching 6 µ in diam. at their apices, faintly colored yellowish.

On burned soil and charred debris. Heart O' Hills, Washington, June 25, 1939, Smith No. *14654*—Type. Additional collections: Mora, May 22, 1939, (*13670, 13674, 13679*); Forks, May 31, 1939, (*13937*); Joyce, June 9, 1939, (*14228, 14219, 14227*). Also Lake Quinault, 1925, collected by C. H. Kauffman.

At least eight species are reported on carbonicolous substrata. However, none of them seems to apply to these collections. *Humaria rustica* Vel. approaches our plant in some respects, but since his description is so brief it is difficult to interpret the species. He gives the spores as "12–18 µ globose ellipticae" which ours definitely are not. *Humarina semiimmersa* (Karst.) Seaver resembles this in being partially immersed in the soil but *H. semiimmersa* grows to a much larger size.

HYALINA CRENATO-MARGINATA v. Höhnel. Frag. z. Mykol. Sitz. Akad. Wiss. Abt. I, Bd. 116, heft 1, Not. III, no. **134.** 1907.

The minute apothecia have delicately dentate margins. Unless wet they are inconspicuous because of their small size.

On *Alnus,* Graves Creek, May 23, 1939, (*13725*); on *Acer circinatum* Pursh, Forks, May 31, 1939, (*13941*).

HYALOPEZIZA CILIATA Fuck. Symb. Myc. p. 298. 1869; v. Höhnel (1918).

This is a minute fungus with apothecia measuring up to 0.6 mm. in diam. It is distinguished in part by the presence of very long strigose hairs which have thick walls and thin septa. The color when fresh is "pinkish buff." The genus *Hyalopeziza* is properly placed in the Hyaloscyphaceae by Nannfeldt (1932). v. Höhnel (l.c.) gave an excellent description of this species.

On *Delphinium* sp., Boulder Lake, 4,500 ft. elev., May 27, 1939, (*13799*).

Hyalopeziza Pteridis sp. nov.

Apothecia minuta, solitaria, sessilia ad substipitata, 175–200 μ in diam., 75 μ alta (basi inclusa), cupuliformia, pellucida, hyalino-alba propter setas excipulares, 75 μ longa, 6 μ lata, asci cylindraceo-clavati, 30–35 × 4.5 μ, octospori; sporae virguliformes, rectae, hyalinae, unicellulae, 4–5.5 × 0.75–1 μ; paraphyses filiformes.

Ad caules vetustas *Pteridis* sp., Lake Quinault, Washington, 2 Junii, 1939, Smith No. *13987,* **Typus.**

Apothecia minute, solitary, sessile to substipitate, 175–200 μ in diam., 75 μ in height (including the base), cup-shaped, translucent, hyaline-white from the excipular hairs; exciple composed of small prismatic cells from which arise long, rough, hyaline, septate hairs 75 μ long, 6 μ at the widest (middle) portion; asci cylindric-clavate, 30–35 × 4.5 μ, eight-spored, spores obliquely arranged in the asci, ascus pore blue with iodine; spores rod-like, straight, hyaline, one-celled, 4–5.5 × 0.75–1 μ; paraphyses filiform.

The genus *Hyalopeziza* was established by Fuckel (1869–1870), but was emended by v. Höhnel (1902), and was placed in the Hyaloscyphaceae by Nannfeldt (1932). It is a small genus. Because of transfers only *H. ciliata* was left in the genus. Nannfeldt made no disposition of *H. caricis* Sacc., but neither *H. ciliata* nor *H. caricis* can be our North American fungus found on fern leaves. *H. ciliata* is said to have large spores and *H. caricis* is reported on *Carex* sp., turns olive black on drying, and has subcapitate hairs.

HYALOSCYPHA ALNISEDA Vel. Monog. Disco. Bohem., pt. 1, p. 283. 1932.

Apothecia minute, 0.1–0.3 mm. in diam., sessile, cup-shaped, substance soft, color pale watery-gray, margin fringed with a single row of one-celled hairs which are bulbous at the origins; asci 30–40 × 5 μ; spores 5–7 × 2 μ, straight to slightly bent, one-celled, hyaline; paraphyses filiform.

On *Alnus* log, Lake Ozette, May 15, 1939, (*13432*).

HYALOSCYPHA HYALINA (Fr.) Boud. Icon. Mycol. 3, pl. 525. 1905–1910.

This minute fungus is scarcely visible to the unaided eye. When moist it is translucent; when dry it takes on a pale yellowish color. The apothecia are sessile and some are turbinate. The marginal hairs are one-celled, stiff, lance-shaped, and they project beyond the asci about 30 μ. The hyaline spores measure 4–6 × 1.5–2 μ, and the paraphyses are filiform.

On alder sticks, Kalaloch, May 2, 1939, (*13074*); on *Rubus* canes, Lower Hoh River, May 18, 1939, (*14542*).

HYSTEROGRAPHIUM PROMINENS (Phill. & Hark.) Berl. & Vogl. Syll. Fung. Additaments ad Volumina 1–4. 1886.

On madrone, Lake Crescent, May 26–June 15, 1939, (*13968, 13747, 13766* and *14360*). Identified by M. L. Lohman.

KARSCHIA LIGNYOTA (Fr.) Sacc. Syll. Fung. 8: 779. 1889.

On *Acer* sp., Lake Crescent, June 13, 1939, (*14351*); on *Rubus* sp., Lake Crescent, June 13, 1939, (*14348*).

KARSCHIA MELASPILEOIDES Rehm. Ascomycetes: Hysteriaceen und Discomyceten. In Rabenh. Krypt. Fl. p. 347. 1890.

This fungus differs from *K. lignyota* in having smaller apothecia. The two-celled spores measure 14–16 × 5–6 μ as compared with 9–12 × 4–5 μ in *K. lignyota.* The apothecia do not turn wine red in iodine. The paraphyses are sparingly branched below the middle and their apices form an epithecium.

On *Populus trichocarpa* T. & G., Hoh River, May 7, 1939, (*13218, 13207*).

KARSCHIA STYGIA (B. & C.) Massee. Jour. Linn. Soc. **35**: 107. 1901. See Butler, p. 814. 1940.

On *Populus trichocarpa,* Hoh River, May 7, 1939, (*13207*).

Lachnaster miniatus sp. nov. (FIGS. 20–23)

Apothecia minuta, alba, 0.1 mm. lata, subsessilia, margo setis longis flagelliformibus praetextus, ad modum dentium dispositis; setae 75–90 × 6–8 µ, septatae, asperae, pallide luteae; asci 30–35 × 5–6 µ; sporae rectae, hyalinae, 6–8 × 1–1.5 µ, paraphyses hyalinae, lanciformes, 50 × 6–7 µ.

Ad *Pteridium aquilinum* (L.) Kuhn, Lake Crescent, Washington, 27 Maii, 1939, Smith No. *13760,* **Typus.**

Apothecia minute, 0.1 mm. broad, very short stipitate to substipitate, white, margin edged with long whip-lash hairs arranged in teeth, hairs 75–90 × 6–8 µ, septate, rough, pale yellow, the lower half broader, abruptly narrowing to the sharp pointed upper portion; asci 30–35 × 5–6 µ, eight-spored, pore blue with iodine; spores straight, hyaline, 6–8 × 1–1.5 µ arranged obliquely in the asci; paraphyses lance-like, hyaline, wider and longer than the asci, 50 × 6–7 µ.

On *Pteridium aquilinum,* Lake Crescent, Washington, May 27, 1939, Smith No. *13760*—Type. Additional collections (*13763* and *13976*).

The genus *Lachnaster* was described by v. Höhnel and is characterized by the marginal hairs of the apothecia being arranged in teeth and by the lance-like paraphyses.

LACHNUM ALBOTESTACEUM (Desm.) Karst. Myc. Fenn. **1**: 175. 1869–1870; Rehm, p. 903. 1893.

The specimens in our collections grew on grass. The apothecia are "vinaceous buff" when fresh, and become whitish in age. "Vinaceous brown" hairs cover the stipe and the outside of the apothecia. The hairs are pale at their apices. Iodine turns them rose lavender. The spores are 6–9 × 1.5 µ. The paraphyses are very long and are sharply pointed.

On grass, Hoh River, May 20, 1939, (*13625*); Hoh River, May 30, 1939, (*14735*).

LACHNUM ALNEUM Vel. Monogr. Disc. Bohem. p. 247. 1934.

Apothecia stipitate on very slender stipes, covered with hairs which are conspicuous by their roughened, spiny projections, hairs short, blunt, rigid; asci 35–40 × 4–5 µ; spores 6–8 × 1.5 µ; paraphyses up to 15 µ in the middle portion, lance-pointed, exceeding the asci by 35–40 µ, not numerous. This is the first report of this species from North America.

On log of *Alnus,* Lake Quinault, May 17, 1939, (*13502*).

LACHNUM BICOLOR (Fr.) Karst. Myc. Fenn. 1: 172. 1871; Rehm, p. 870. 1893.

On *Alnus,* Hoh River, May 7, 1939, (*13211*); on debris of alder, Sol Duc Park Trail, 4,600 ft. elev., June 20, 1939, (*14483*).

LACHNUM CALYCULAEFORME (Fr.) Karst. Myc. Fenn. 1: 178. 1871.

The color of the hymenium in fresh plants is "tilleul buff," and the exterior is "wood brown." On decorticated wood, Lake Crescent, June 3, 1939, (*14017*).

LACHNUM CLANDESTINUM (Fr.) Karst. Myc. Fenn. 1: 178. 1871.

This species has been frequently and widely collected on *Rubus* spp. although it is not restricted to that substratum. The long, rough, brown hairs with the conspicuous crystal formation at the tips together with the uniform spores (7–9 × 1–1.5 µ) are some of the characters which distinguish it.

On twigs of willow (?), Spruce, May 19, 1939, (*13583*); on woody stems of nettle, Port Ludlow, May 30, 1939, (*13995, 13901*); on *Acer circinatum,* May 30, 1939, (*13907*); on *Rubus* canes, June 13, 1939, (*14347*).

LACHNUM CORTICALE (Pers. ex Fr.) Nannf. Nova Acta Regiae Societatis Scientiarum Upsaliensis ser. IV. 8 No. 8. p. 265. 1932.

Nannfeldt has shown the above name is the tenable one for this fungus. It has previously been known under several other names;

among them are—*Pezisa corticalis* Pers. and *Lachnella corticalis* (Pers.) Fr. Boudier (1905–1910) has an excellent illustration of it under the latter name. Velenovský (1934) described a species as *Lachnum corticale,* which name according to the International Rules of Nomenclature is invalid. The name **Lachnum bohemicum** nom. nov. is proposed.

On root of *Rubus* sp., Hoh River, May 7, 1939, (*13210*).

LACHNUM FLAVOFLOCCOSUM Rehm. Ann. Myc. **5**: 520. 1907.

The bright brown color of the apothecia is characteristic. The cups are sessile and gregarious. The spores are fusoid and measure 7–9 × 1.5 μ. The paraphyses are conspicuous, acutely lance-pointed and are unusually long. This species was described on *Lonicera* sp. from a collection made at Sumner, Washington, by E. T. and S. A. Harper, 1906.

On *Lonicera* sp., Cape Flattery, May 27, 1939, (*13794*).

LACHNUM FLAVO-FULIGINEUM (Fr.) Rehm, p. 888. 1888.

The brown hairs are very long and numerous on the outside of the cups, and they bear no crystals. The spores measure 9–10 × 2.5–3 μ.

On sticks, Lake Crescent, June 3, 1939, (*14033*); on *Sambucus* sp., Lower Elwha River, July 3, 1939, (*14746*).

LACHNUM GAULTHERIAE Zellet. Mycologia **26**: 292. 1934.

On leaves of *Gaultheria shallon* Pursh, Lake Crescent, June 2, 1939, (*13974*).

LACHNUM HYALINELLUM Rehm. Ann. Myc. **5**: 398. 1917.

On *Alnus* cones, Clearwater River, May 9, 1939, (*13288*); on wood, Jackson Guard Station, May 13, 1939, (*13389*); on sticks, Lake Quinault, May 17, 1939, (*13504, 13492*); on old conifer wood, Hoh River, May 18, 1939, (*13526*); on *Alnus* cones, Port Ludlow, May 30, 1939, (*13892*); on *Alnus* cones, Lake Crescent, June 2, 1939, (*13984*); on *Alnus* wood, Joyce, July 6, 1939, (*14841*).

This species is commonly collected. Rehm made a distinction between the fungus growing on the wood and on the fruits of *Fagus silvaticus*. For the fungus growing on the fruits he gave the name *forma fructicolum*. Our collections were made on the cones and on the wood of *Alnus* sp. They seem to be exactly alike and they differ only slightly from Rehm's description. The hairs are slightly roughened in contrast to the condition reported by Rehm. In view of the fact that the fungus as represented by our western collections does not seem to be differentiated on the basis of substratum, it may be found that the form distinction made by Rehm is not significant. The slight roughness on the hairs of the American material does not prevent its being named as above.

LACHNUM NARDI Rehm, p. 883. 1888.

This is a minute stipitate fungus with long, rough, septate hairs which at the margin of the apothecium are clustered in fascicles. The spores are small, and measure 5–7 × 1 μ. The paraphyses are broadly lanceolate and extend 30 μ beyond the asci. The hairs turn violet in iodine solution. This species is distinguished from others on sedges by its small spores. It resembles *L. carneolum* (Sacc.) Rehm which is reported on grass. Rehm gives the spore size as similar to *L. nardi* but the original description gives the spores as considerably larger in both length and width. The fungus is white when fresh.

On sedge, Lake Crescent, June 3, 1939, (*14035, 14023*); June 4, 1939, (*14067*).

LACHNUM NIVEUM (Fr.) Karst. Myc. Fenn. 1: 168. 1871.

The apothecia are short stipitate, and are covered with rough, hyaline hairs. The spores measure 6–8 × 1.5 μ. The paraphyses are lance-shaped. A peculiarity of the hairs is that they turn pale violet in iodine. Saccardo described *L. crystalligerum* from a specimen on *Rubus parviflorus* from Spokane, Washington, but the two species are distinct. In the latter species the hairs are tipped with large crystals and the asci and spores are considerably larger.

On *Rubus* sp., Kalaloch, April 27, 1939, (*13009*); June 13, 1939, (*14343*); Forks, June 18, 1939, (*14437, 14440*).

LACHNUM PALLIDE-ROSEUM (Saut.) Rehm, p. 885. 1893.

This is a delicate, stipitate plant with the hymenium "vinaceous buff" when fresh. On drying it becomes rose red. The outside of the cup is white from the short, rough hairs. The spores measure 7–10 × 1.5 μ. The paraphyses are very large, prominent and exceed the asci.

On grass stems, Hoh River, June 30, 1939, (*14722*).

LACHNUM SETIGERUM (Phill.) Rehm. Ann. Myc. 3: 518. 1905.

This species was described from material collected in California on a species of *Aralia*. The apothecia are covered with stiff, brown, septate hairs the tips of which are nearly globose and nearly hyaline. The spores are straight and hyaline and measure 9–12 × 2 μ. The ascus pore is not blue in iodine.

On Devil's Club, Forks, May 31, 1939, (*13926*).

LACHNUM SPIRAEAECOLUM (Karst.) Rehm, p. 880. 1893.

On stems of nettle, Port Ludlow, May 30, 1939, (*13909*).

LACHNUM SULFUREUM (Fr.) Rehm, p. 891. 1893.

This species is found commonly and on a wide variety of substrata.

On herbaceous stems, Hoh River, May 18, 1939, (*13529*); on *Sambucus* sp., Forks, May 31, 1939, (*13935*); on stems of *Rubus* sp., Lake Crescent, June 13, 1939, (*14300, 14344*).

LACHNUM VIRGINEUM (Fr.) Karst. Myc. Fenn. 1: 169. 1871.

Seven collections were made on sticks: Clearwater River, May 9, 1939, (*13287*); Kalaloch, May 10, 1939, (*13307*); Lower Hoh River, May 18, 1939, (*13537, 13539*); Lake Crescent, June 4, 1939, (*13985*); Lake Crescent, June 3, 1939, (*14034*); Sol Duc Park Trail, 4,000 ft. elev., June 20, 1939, (*14479*).

LAMPROSPORA CARBONARIA (Fuck.) Seaver. Mycologia **6**: 16. 1914; North American Cup-fungi, p. 67. 1928.

On burned soil, Olympic Hot Springs, May 28, 1939, (*13807*); on soil, Joyce, July 5, 1939, (*14799*).

LAMPROSPORA CREC'HQUERAULTII (Cr.) Boud. Icon. Mycol. **1905–1910**; Seaver, North American Cup-fungi, p. 62. 1928.

On wet soil, Lake Crescent, June 3, 1939, (*14022*).

LAMPROSPORA HAEMASTIGMA (Fr.) Seaver. Mycologia **6**: 17. 1914; Seaver, p. 68. 1928.

On soil, Spruce, May 19, 1939, (*13583*); on leaf content in dung, Spruce, May 19, 1939, (*13583*); on soil, Hoh River, June 30, 1939, (*14716*).

LAMPROSPORA LEIOCARPA (Curr.) Seaver. Mycologia **6**: 21. 1914; North American Cup-fungi, p. 73. 1928.

On burned soil, Mora, May 22, 1939, (*13667*); Olympic Hot Springs, May 28, 1939, (*13813*); Mora, May 31, 1939, (*13946*); Forks, May 31, 1939, (*13940*); Sol Duc River, May 31, 1939, (*13945*).

Number *13946* is an unusually large plant. When dry the disk measured 4.5 cm. in diameter.

LASIOBOLUS EQUINUS (Mull.) Karst. Act. Soc. Fauna Fl. Fenn. **2**: 122. 1885; Seaver, p. 155. 1928.

On elk dung, Kalaloch, April 29, 1939, (*13007*); May 2, 1939, (*13070, 13077*); on dung, Hoh River, May 20, 1939, (*13624*); on cow dung, Lake Crescent, May 22, 1939, (*13835*); on raccoon dung, Joyce, June 9, 1939, (*14220*); on dung, Cape Flattery, June 27, 1939, (*13782*).

LOPHODERMIUM PINASTRI (Fr.) Chev. Flora Paris 1: 430. 1926; Rehm (**1887–1896**), p. 43. 1887.

On conifer twig, Lake Crescent, June 15, 1939, (*14382*).

MELASTIZA CHARTERI (W. G. Smith) Boud. Hist. Class Discom. Eur. p. 64. 1907; Boud. Icon. Mycogr. pl. 45, fig. 17. 1905–1910; Seaver, p. 103. 1928.

Apothecia bright red, color revives in water, delicate, hyphae-like hairs are short, blunt, thin-walled and are pale brown in color, sparse, and tend to become grouped into bundles; mature spores coarsely warted, apiculate, 18–20 × 10–12 μ; paraphyses slender, widening abruptly at the apices into clavate or bulbous swellings reaching 18 μ in diam.

On earth, Pyscht River, Sept. 25, 1935, (*2671*); Mt. Angeles, Sept. 28, 1939, (*17378*), collected by H. V. Smith. To the synonymy of this species as given by Seaver (1928) add: *Lachnea pseudotrechispora* Rehm, *Humariella pseudotrechispora* Schröter, and *Aleurina pseudotreichospora* (Schröter) v. Höhnel apud Rehm. There seems to be no difference between these and *Pesiza charteri* W. G. Smith. The combination of the two characters—presence of hairs on the exciple together with the warty apiculate spores—prevents this fungus from being placed in any of the following genera: *Lachnea, Aleuria, Humaria* or *Humariella.* The collection from the Olympic National Park fits Seaver's description.

MELITTOSPORIUM SCHNABELIANUM (Rehm) v. Höhnel. Frag. zur Mycol. IX Mitt. nr. 450, p. 1518. 1909.

Disc erumpent, then flat, marginate, dark gray-purple, powdered with white particles, 0.5–1.5 mm. in diam., asci 120–150 × 9–12 μ, usually four-spored, ascus pore reddish purple in iodine; spores muriform, four-celled, 18–20 × 9–10 μ; paraphyses filiform, branched above, forming an epithecium.

On stick, Lake Crescent, June 3, 1939, (*14029*).

Rehm described this fungus under the name *Belonidium Schnabelianum* although he recognized that it did not properly belong in the genus *Belonidium.* The muriform spores together with the erumpent habit are characters of the genus *Melittosporium.* V. Höhnel (l.c.) pointed this out and made the transfer to that genus. Sydow and Saccardo (1899) proposed the name *Schnablia* for this species but v. Höhnel's treatment is preferred.

MICROPODIA PTERIDINA (Nyl.) Boud. Icon. Mycogr. 3. pl. 527. 1905–1910.

Apothecia minute, stipitate, 200 μ in diam., 100 μ in depth, excipular cells on the lower one-half of the cup arranged in scale-like triangular patches overlapping like shingles on a roof, color of the lower part of each scale light sordid brownish shading to nearly hyaline at the tips; margin bordered by similar cell groups, from twenty to twenty-five at the edge of each cup; stipe 40–50 μ in height by 40 μ in width; asci 25–30 × 4–5 μ; spores straight, hyaline, one-celled, 4–6 × 1–1.5 μ; paraphyses filiform.

On *Pteridium aquilinum* (L.) Kuhn, Forks, June 6, 1939, (*14147*).

This fungus was named *Peziza pteridina* by Nylander. It resembles a *Helotium* but it is much smaller in size of cup, asci and spores. Also the excipular cells are different from those found in *Helotium* spp. This is not *Peziza pteridina* Pers. ex Fr. which is described as a sessile plant.

MITRULA CUCULLATA (Batsch) Fr. Summ. veg. Scand. p. 337. 1849; Durand, p. 402. 1908.

On hemlock needles, Lake Quinault, Oct. 19, 1925, collected by C. H. Kauffman; on fir needles, La Push, Oct. 25, 1935, (*3336*). Identified by E. B. Mains.

MITRULA PHALLOIDES (Bull.) Chev. Flor. de Paris. 114, 1826.

On wet soil, Kalaloch, May 10, 1939, (*13301*). Identified by E. B. Mains.

MOLLISIA AMENTICOLA (Sacc.) Rehm. 1887–1896. p. 540. 1891.

The marginal hairs are palisade-like and are pale in color, whereas the excipular cells below are hexagonal, small and dark-colored. The spores measure 6–9 × 1.5–2.5 μ.

On cones of *Alnus* sp., Kalaloch, April 27, 1939, (*1258*).

MOLLISIA BENESUADA (Tul.) Phill. Manual Brit. Disco. p. 174, 1887.

This is one of the light-colored species. The spores measure 8–10 × 2–2.5 μ.

Kalaloch, May 10, 1939, (*13312*); on dead wet sticks, Jackson Guard Station, May 13, 1939, (*13381*); Lake Quinault, May 17, 1939, (*13501*); Cape Flattery, May 27, 1939, (*13789*); Port Ludlow, May 30, 1939, (*13893*); Lake Crescent, June 15, 1939, (*14387*).

MOLLISIA CAESPITICIA Karst. Myc. Fenn. 1: 188. 1871.

On sticks, Lower Hoh River, May 18, 1939, (*13531*); on *Alnus* sp., Boulder Lake, May 28, 1939, (*13810*); on sticks, Port Ludlow, May 30, 1939, (*13911*); on crabapple, Forks, June 18, 1939, (*14438*).

MOLLISIA CINEREA (Batsch.) Fr. Syst. Myc. 2: 142. 1823.

Queet's River, May 3, 1939, (*13094*); Hoh River, May 7, 1939, (*12314*); Clearwater River, May 9, 1939, (*13296*); Lake Ozette, May 16, 1939, (*13439, 13437*); Lower Hoh River, May 18, 1931, (*13540, 13546*); Graves Creek, May 25, 1939, (*13729, 13726*).

MOLLISIA COMPLICATULA Rehm. 1887–1896. p. 520. 1891.

Apothecia inrolled, brown-black in color; asci 50–60 × 6–7 μ; spores 9–12 × 2–2.5 μ.

On *Lonicera* sp., Cape Flattery, May 27, 1939, (*13794, 13788*).

Rehm described this species from a collection on *Lonicera* from the Tyrol.

MOLLISIA REVINCTA Karst. Myc. Fenn. 1: 195. 1871.

The apothecia are brownish on the outside, have a whitish margin and light gray hymenium. The spores measure 8–11 × 1.5–2 μ. Rehm (1914) mentioned a form *Rubi* on *Rubus idaeus* but he did not give a description. What he considered a difference other than a difference in substrata is not known. Our collections seem to be the typical variety and there is no essential difference between those found on herbaceous stems and those on *Rubus* canes.

On herbaceous stems, Hoh River, May 18, 1913, (*13523, 13528*). The following collections were from stems of *Rubus* sp., Kalaloch, May 2, 1939, (*13072*); Forks, June 18, 1939, (*14439*).

MORCHELLA CONICA Pers. ex Fr. Summa veg. Scand. 316. 1849; Seaver, p. 239. 1928.

Jackson Guard Station, May 13, 1939, (*13380*); Hoh River, June 6, 1939, (*14146*); Lake Angeles, June 25, 1939, (*14640*); Lake Angeles, June 28, 1939, (*14671*).

MORCHELLA CRASSIPES Fr. Syst. Myc. 2: 9. 1823; Seaver, p. 237. 1928.

Under spruce, Hoh River, May 19, 1939, (*13552*); in *Alnus* flat, Graves Creek, May 23, 1939, (*13693*).

MORCHELLA ESCULENTA Pers. ex Fr. Syst. Myc. 2: 6. 1823; Seaver, 1928. pl. 36. fig. 2.

Lake Angeles, June 25, 1939, (*13173*).

NIPTERA MELATEPHRA (Lasch) Rehm, p. 558. 1891.

On sedge, Lake Crescent, June 4, 1939, (*14068*). In the sense of Rehm this is a typical collection with large two-celled spores.

OCELLARIA AUREA (Tul.) Rehm, p. 134. 1888.

On *Salix* sp., Whiskey Creek Beach, Joyce, June 22, 1939, (*14554*).

OMBROPHILA FLAVENS Feltg. Pilz Flora. 1. Thiel. Ascom. Nacht. III. 76. 1903.

Apothecia single or scattered, sessile to substipitate, 1.5 mm. in diam., dull yellow to pallid yellow when fresh, drying darker, exciple slightly roughened; asci 70–75 × 7–8 μ, pore blue in iodine; spores one-celled, hyaline, containing large oil drops, (9)11–13 × 3–4 μ; paraphyses filiform.

On dead wood of *Salix* sp., Lake Crescent, June 3, 1939, (*14027*). This species was described from a collection on *Salix*. V. Höhnel reported that there is but scanty material left in the type collection. However, from Feltgen's description it seems safe to assume that our fungus is his species.

OMBROPHILA LIMOSELLA (Karst.) Rehm, p. 476. 1891.

Kalaloch, April 23, 1939, (*13051*); on sticks, Kalaloch, May 2, 1939, (*13069*); on debris, Cape Flattery, May 27, 1939, (*13793*).

Ombrophila Lysichitonis sp. nov. (FIGS. 24–25)

Apothecia 3–6 mm. in diam., 3–6 mm. alta, subturbinata, álbida ad griseo-rosea, mollia, gelatinosa; hypothecium praeter stratum gelatinosum magnis cellulis subglobosis, stratum excipulare pubescens; asci cylindracei, 125–150 × 9–10 μ; sporae ellipsoideae, 11–14 × 6–8 μ, unicellulae, hyalinae; paraphyses filiformes, plurimae.

Ad carnem circum fructos *Lysichitonis camtschatcensis* (L.) Schott., Kalaloch, Washington, 10 Maii, 1939, Smith No. *13299*, **Typus**.

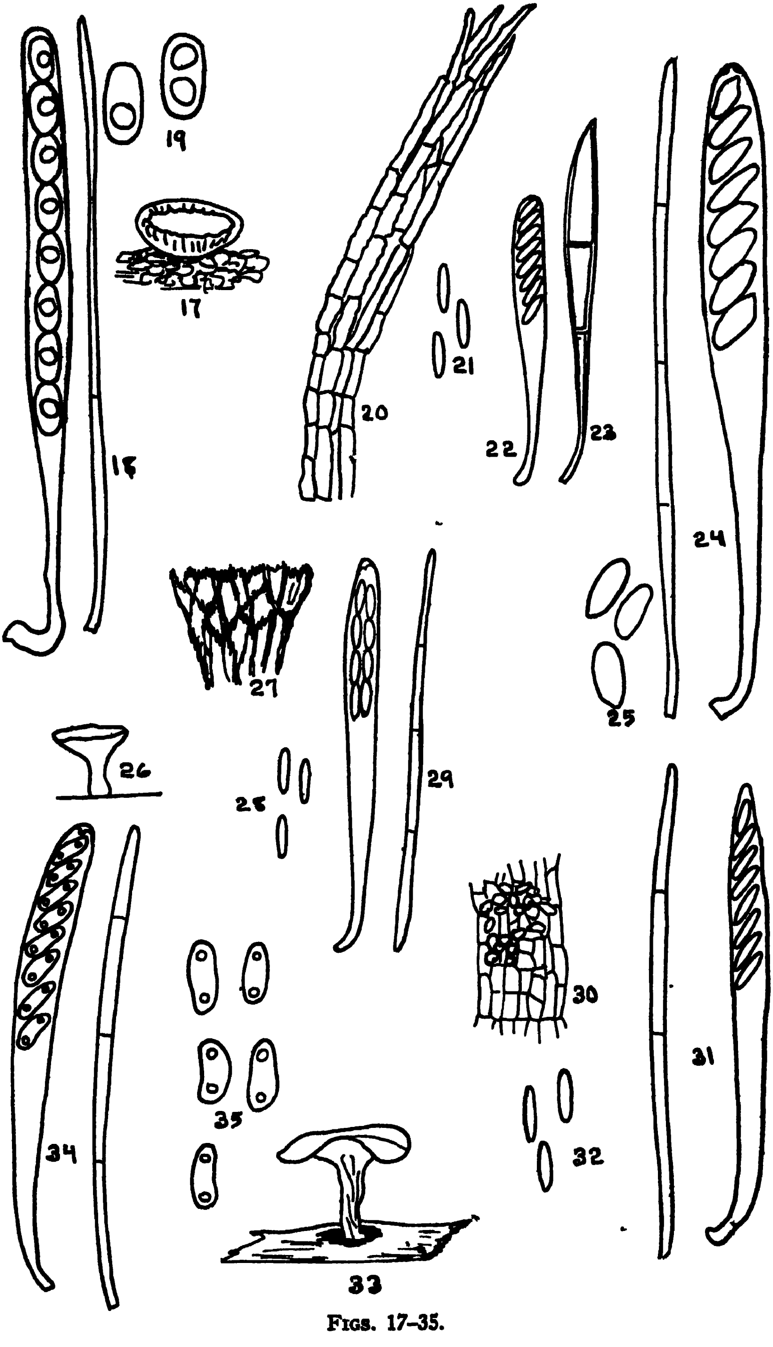
Apothecia 3–6 mm. in diam., 3–6 mm. high, subturbinate to short stipitate, stipe if present, short, thick, expanding broadly into the cup, white tinged grayish-pink, concolorous throughout, substance soft, gelatinous, a thin gelatinous layer lying directly below the hymenium: hypothecium other than the gelatinous layer made of large, loosely arranged subglobose cells, excipular layer embellished by a minute delicate pubescence made of the extension of the outermost layer of excipular cells which give a slightly velvety appearance; asci cylindric, 125–150 × 9–10 μ, frequently long-stalked, eight-spored, pore blue with iodine; spores 11–14 × 6–8 μ, hyaline, one-celled, inequilateral ellipsoid; paraphyses filiform, numerous, hyaline.

OMBROPHILA MICROSPORA (E. & E.) Sacc. & Syd. Syll. Fung. **14**: 187. 1899; Ellis, Bull. Torr. Bot. Cl. **24**: 282. 1871.

Apothecia "russet vinaceous" when fresh, up to 6 cm. in diam.; asci 70–80 × 6–7 μ, pore not blue with iodine; spores 5–6 × 2.5–3 μ.

On inner bark of *Populus trichocarpa*, Hoh River, May 7, 1939, (*13208*).

There are at least five other species of *Ombrophila* described in which the spores are small, but in each case there are morphological characters that prevent our fungus from being referred to any one of them. These small-spored species are *O. spelunarum* Legardo;



FIGS. 17–35.

O. violacea var. *rosiae* P. Henn.; *O. pellucida* A. L. Smith; *O. blumenavensis* P. Henn.; and *O. microsperma* P. Henn. Ellis (l.c.) called this a *Coryne* but the non-septate spores place it in the genus *Ombrophila.*

ORBILIA PARADOXA Vel. Monogr. Disc. Bohem., pt. 1. p. 102. 1934.

On *Alnus* log, Lake Quinault, May 17, 1939, (*13503*); on *Alnus* log, Elwha River, June 23, 1939, (*14594*).

OSTROPA CINEREA Fr. Summa veg. Scand. 1849; Rehm 1887–1896. p. 188. 1888.

On *Rubus* sp. (?), Lake Crescent, June 13, 1939, (*14350*).

OTIDEA ABIETINA (Fr.) Fuck. Symb. Myc. p. 330. 1869-1870.

This fungus is one of the older species which in the years since Persoon described it as a *Peziza* has been placed in several genera. The split apothecia determine its present position in the genus *Otidea.* It differs from *O. grandis* (Fr.) Rehm in having filiform paraphyses, slightly larger spores (18–22 × 10–12 μ), and apothecia that are lighter in color.

On muck, Lake Quinault, May 17, 1939, (*13506*).

OTIDEA CANTHARELLA (Fr.) Sacc. var. MINOR Boud. Icon. Mycogr. 2. pl. 326. 1905–1910.

Apothecia 1–3 cm. in diam., with a truncated top, split on one side, light colored; spores elliptical, smooth, 13–15 × (5)6–9 μ, containing two guttulae; paraphyses measuring 6–7 μ at their apices, and extending beyond the asci.

On gravel in road, Clearwater River, May 24, 1939, (*13738*).

OTIDEA FELINA (Pers. ex Fr.) sensu Bres. Iconogr. Mycol. 25: taf. 1228. 1933.

Elwha River, Sept. 27, 1941, (*17338*); Olympic Hot Springs, Oct. 8, 1941, (*17699*).

In many respects these collections resemble *O. felina* sensu Bres. The chief difference is in the size of the apothecia. Our specimens measure up to 7–8 cm. in height and 7 cm. in width, whereas those described and illustrated by Bresadola (l.c.) are only 3–4.5 cm. in height and 2–3 cm. in width. Bresadola's interpretation of the species seems to be in marked contrast with Persoon's description which calls for a gray plant. Neither do any of the species put into synonymy by Bresadola agree too well with his description. Fries gave the name *Peziza leporina* var. *cinerea* to Persoon's fungus and hence followed Persoon in accepting the idea of grayness. Unfortunately we do not have color notes on fresh plants, but it is difficult to imagine that the pale ochraceous-buff color of the dried specimens was ever any shade of gray. For the present it seems best to place these data on record in the hope that further study will clear up the questions.

OTIDEA LEPORINA Fuck. Symb. Myc. p. 329. 1869–1870; Seaver, p. 85. 1928 (as *Scodellina leporina* (Batsch) S. F. Gray).

Lake Quinault, Oct. 13, 1925, collected by C. H. Kauffman and C. A. Brown; Bremerton, Oct. 26, 1942, collected by J. B. Flett.

OTIDEA PLEUROTA (Phill.) Sacc. Syll. Fung. 8: 97. 1889; Rehm 1887–1896. p. 1028. 1894.

On soil, Lake Quinault, Oct. 21, 1925, collected by C. H. Kauffman.

This seems to be a new record for North America. The species is adequately described by Rehm (l.c.). It is distinguished from most species of *Otidea* by its dark brown color. The spores are rough and paraphyses are straight with clavate tips. The ascus pore shows a strong bluing reaction. *Otidea Smithii* Kanouse was described (Kanouse, 1939) from specimens collected in California by A. H. Smith in 1937. This species is also dark brown in color but its paraphyses are strongly bent. The spores in *O. Smithii* are rough.

OTIDELLA FULGENS (Fr.) Sacc. Syll. Fung. 8: 99. 1889.

Seaver (1928) placed this fungus in the genus *Pseudoplectania*. This seems to be an unnatural and forced position. The fungus differs markedly from *P. melaena* (Fr.) Sacc. and *P. nigrella* (Fr.) Fuck. not only in its bright orange color but also in the near-absence of hairs on the exciple. At least seven other interpretations have been offered as to the generic position. According to the International Rules of Nomenclature Saccardo's combination is the valid name for those who regard the fungus as generically distinct from other Discomycetes.

On soil, Deer Lake Trail, 4,000 ft. elev., May 11, 1939, (*13331*); June 13, 1939, (*14312*).

PATELLARIA LECIDEOLA Fr. Summa veg. Scand. 151. 1849; Rehm, p. 330. 1890.

Apothecia small, thin, black, exciple composed of dark brown cells arranged over-lapping like shingles on a roof; asci six to eight-spored; spores four-celled, hyaline, 12–14 × 5–6 μ; paraphyses form a thick, brown epithecium.

On *Acer circinatum*, Olympic Hot Springs, June 5, 1939, (*14104*).

PATELLARIA SUBVELATA E. & E. Journ. Myc. 1: 252. 1885.

This species was described from material collected in Washington on a living conifer tree. Its outstanding character is the shape of the spores. They are clavate-fusoid, slightly curved and markedly pointed at one end. They are yellowish in color.

On decorticated sticks of fir, Lake Crescent, June 15, 1939, (*14388*).

PATELLEA CALIFORNICA Rehm, Ann. Myc. **10**: 55. 1912.

This species was described from Southern California on dead *Adenostoma fasciculatum* Hook. & Arn. It has a minute, glabrous, black disc with two-celled hyaline spores, which measure 9–12 × 2–3 μ. The paraphyses are sparingly branched, colored and form an epithecium.

On madrone, Lake Crescent, May 27, 1939, (*13765*); June 2, 1939, (*13973, 13977*). It was also collected at Takilma, Ore., in 1925, on madrone by C. H. Kauffman and C. A. Brown.

PAXINA DUPAINII (Boud.) Seaver. North American Cup-fungi, p. 207. 1928.

On ground, Elwha River, June 10, 1939, (*14582*).

PAXINA HISPIDA (Schaeff.) Seaver. North American Cup-fungi, p. 205. 1928.

On ground, Elwha River, June 10, 1939, (*14262*); Marymere Falls, Lake Crescent, June 25, 1939, (*14657*).

PAXINA NIGRELLA Seaver. North American Cup-fungi, p. 208. 1928.

On hemlock branches on ground, Kalaloch, April 29, 1939, (*13004*); on decayed wood, Cape Flattery, May 27, 1939, (*13795*); Boulder Lake Trail, 4,500 ft. elev., May 28, 1939, (*13809*); Hoh River, May 19, 1939, (*14016, 13583*); Lake Crescent, June 3, 1939, (*14016*); on decorticated wood, Deer Lake Trail, June 13, 1939, (*14331*).

PAXINA MACROPUS (Fr.) Seaver. North American Cup-fungi, p. 203. 1928.

On humus flat, Lake Quinault, May 17, 1939, (*13489*); Hoh River, May 19, 1939, (*13583*); Lake Crescent, June 3, 1939, (*14016*); Elwha River, June 12, 1939, (*14282*).

PAXINA SUBCLAVIPES (Phill. & Ellis) Seaver. North American Cup-fungi, p. 206. 1928.

Lake Crescent, May 17, 1939, (*13505*).

PERROTIA FLAMMEA (Fr.) Boud. Hist. Class. Discom. Eu. 66. 1907.

On madrone, Lake Crescent, June 2, 1939, (*13978*).

PEZIZA BADIA Fr. Syst. Myc. 2: 46. 1823; Seaver, p. 221. 1928.

On soil and old wood, Hoh River, May 7, 1939, (*13174*); May 20, 1939, (*13622*); Graves Creek, May 25, 1939, (*13719*); Lake Quinault, Nov. 5, 1939, collected by C. A. Brown.

PEZIZA BRUNNEOATRA (Gill.) Seaver. North American Cup-fungi, p. 222. 1928.

On mossy debris on cottonwood logs, Hoh River, June 6, 1939, (*14152*); on soil, Hoh River, June 30, 1939, (*14713*); on wet soil, Joyce, July 5, 1939, (*14798*).

PEZIZA FIMETI (Fuck.) Seaver. North America Cup-fungi, p. 232. 1928.

On elk dung, Graves Creek, May 23, 1939, (*13720*); Elwha River, June 23, 1939, (*14595*).

In both of these collections the spores measure 18–20 × 9 μ which measurements are slightly larger than those given by Fuckel or by Seaver who report them to be 16 × 8 μ.

PEZIZA MELALEUCOIDES Seaver. North American Cup-fungi, p. 225. 1928.

This is a clear-cut species and is readily identified by Seaver's description. The nearly black hymenium and the small spores are two distinctive characters.

Deer Lake Trail, May 11, 1939, (*13332, 13377*); Boulder Lake Trail, May 28, 1939, (*13798*); on burned soil, Mora, May 31, 1939, (*13943*); on conifer log, Olympic Hot Springs, June 5, 1939, (*14086, 14645*); Deer Lake Trail, June 13, 1939, (*14320*); Hurricane Ridge, June 17, 1939, (*14420*); on soil, Heart O' Hills, June 19, 1939, (*14434*); Sol Duc Park Trail, June 20, 1939, (*14490*); on decayed wood, Hurricane Ridge, July 7, 1939, (*14857*).

PEZIZA PUSTULATA Fr. Syst. Myc. 2: 55. 1823; Seaver, p. 224. 1928.

On burned soil, Forks, May 11, 1939, (*13928*); on burned soil, Mora, May 22, 1939, (*13666, 13669*); on soil, Graves Creek, May 23, 1939, (*13722*).

PEZIZA REPANDA Fr. Syst. Myc. 2: 51. 1823; Seaver, p. 231. 1928.

On cottonwood log, Elwha River, June 8, 1939, (*14185*).

PEZIZA SYLVESTRIS (Boud.) Sacc. & Trott. Syll. Fung. **22**: 612. 1913; Seaver, p. 233. 1928.

On soil, Hoh River, June 6, 1939, (*14155*); Deer Lake, June 24, 1939, (*14616*); Sequim, July 7, 1939, (*14865*).

PEZIZA SEPIATRA Cke. Grev. **3**: 119. 1874.

This is a small fungus for the genus *Peziza*. It is broadly sessile to substipitate and measures 1.5 cm. or less in diameter. The margin is upraised. It is cinnamon brown throughout. The ascus pore is blue with iodine. The spores are smooth, hyaline, and measure 18–20 × 12 μ. This species has not been reported from the United States as far as can be determined.

On sandy roadside, Elwha River, June 12, 1939, (*14289*).

PEZIZA VIOLACEA Fr. Syst. Myc. **2**: 65. 1823; Seaver, p. 226. 1928.

On burned ground, Mora, May 22, 1939, (*13664*); Joyce, June 9, 1939, (*14225*).

PEZIZELLA MICROPSIS (Karst.) Sacc. Syll. Fung. **8**: 281. 1889; Rehm, p. 679. 1892.

Rehm gives a good description of this species. The fungus is small, sessile, white. On drying it becomes yellowish. The exciple is delicately pubescent. The asci measure 30 × 5–6 μ, and the spores are 6–8 × 1.5–2 μ.

On sedges, Lake Crescent, June 4, 1939, (*14069*).

PEZIZELLASTER RADIOSTRIATA (Feltg.) v. Höhnel. Ann. Myc. **15**: 349. 1917.

Apothecia minute, sessile, white, hymenium "light vinaceous buff," hairy, the marginal hairs hyaline, rough, arranged in definite teeth, the hymenial layer brown with iodine; asci eight-spored, 35–40 × 5–6 μ; spores 8–9(10) × 1.5 μ, hyaline, one-celled; paraphyses slender with pointed apices.

On old stems of nettle, Port Ludlow, May 30, 1939, (*13905, 13902*).

PSEUDOCIBORIA UMBRINA Kanouse. Mycologia 36: 460. 1941.

This species was described from material collected on decayed *Alnus* leaves. The characteristic feature of the species is that there are two types of paraphyses—one type filamentous and hyaline and the other cylindric and dark brown.

Lake Crescent, June 3, 1939, (*18933*).

PHIALEA ALNIELLA (Nyl.) Sacc. Syll. Fung. 8: 257. 1889.

This species seems to be very closely related to, if not identical with, *Helotium gemmarum* Boud., which has been reported on catkins of *Alnus glutinosa*. Both are described as being small stipitate fungi with a yellowish color in a portion of the stipes. Both have asci about 50 × 6 μ and spores that measure 6–9 × 2–3 μ. The species is a delicate plant and is probably better placed in the genus *Phialea* than in *Helotium*. Rehm placed *Hymenoscypha alniella* Schröt. in synonymy with *Phialea alniella*.

On maple seed, Elwha River, June 23, 1939, (*14597*).

Phialea cyathoidea var. **minutula** (Sacc.) comb. nov.

Saccardo described *Phialea minutula* and said of it that it could be distinguished from *P. cyathoidea* by its smaller asci and spores. He reported the measurements of the asci as 30–35 × 5 μ and the spores as 6–7 × 1.5 μ. According to Rehm, *P. cyathoidea* has asci and spores that measure 45–50 × 4.5–5.5 μ and 5–11 × 1 μ respectively. Our specimens have the measurements of those given by Saccardo for *P. minutula*. The two species are apparently closely related and in my estimation the specimens with the small spores and asci are at most but a variety of *P. cyathoidea*. The plant is stipitate, delicately scalloped at the margin and is white throughout.

On herbaceous stems, Lower Hoh River, May 18, 1939, (*13534*).

PHIALEA DISCRETA (Karst.) Rehm (1887–1896), p. 729. 1893.

This is a fragile plant yellowish in color with asci that measure 40–50 × 4 μ and spores that measure 6–8 × 1.5–2 μ.

On gooseberry cane, Lake Crescent, June 13, 1939, (*14357*).

Phialea olympiana sp. nov. (FIGS. 26–29)

Apothecia gregaria, stipitata, 1 mm. in diam., firma, carnosa, "luteoso-citrina" in humido, exsiccanda nigricantia. Stipes gracilis, ad 1 mm. longus, levis, albus, ascoma stipesque rete hypharum nigro-brunneis incrustationibus extus striata. Margo pseudodentata. Hypothecium pseudoprosenchymaticum. Asci cylindracei 35–45 × 5 μ; sporae rectae, hyalinae, unicellulatae, 6–8 × 1 μ; paraphyses filiformes.

Ad caules herbarum, Forks, Washington, 6 Junii, 1939. Smith No. *14148*, **Typus.**

Apothecia gregarious, stipitate, 1 mm. in diam., firm fleshy, "yellowish citrine" when moist, drying blackish; stipe slender, up to 1 mm. long, smooth, hyaline white, the outside of the cup and stipe streaked with a rope-like net of hyphae with dark brown incrustations which give a black, glistening appearance in the dry condition. Margin pseudodentate from the incrustations; hypothecium pseudoprosenchymatic of small densely compacted interwoven hyphae which make almost a cellular appearance; asci cylindric, 35–45 × 5 μ, ascus pore not blue with iodine; spores cylindric, straight, hyaline, one-celled, 6–8 × 1 μ; paraphyses filiform.

This is a close relative of *P. cyathoidea,* but has smaller spores, larger asci and lacks the rose color in the apothecia. Without question many unanswered problems exist with regard to the genera *Helotium, Hymenoscypha* and *Phialea* and it is difficult to assign species accurately in the genus *Phialea* until some of these basic problems are solved and clear generic limitations established. Yet the two species described as new in this paper cannot be forced into any other known genera. They do not conform to the rather sturdy waxy fungi with fairly large spores and asci that are found in the genera *Helotium* and *Hymenoscypha.* They are soft, delicate plants with small spores and small asci. The delicate markings on the exterior of the cups in both species is a character rarely found in species of *Helotium.*

Phialea pallida sp. nov. (FIGS. 30–33)

Apothecia gregaria, stipitata, sine stromate, mollia, ceracea, 0.5 mm. in diam., 0.5 mm. alta, cupulata remanentia, margine erecto, in sicco involuto, pallide olivaceo-carnoso, in sicco flavido; stipes 200–300 μ longus, 150–200 μ in diam., apotheciis concolor, excipulum minute floccosum a cellulis melleis, minutis, subglobosis quae squamae simulant; asci cylindracei, 70–80 × 6–7 μ; sporae cylindraceae, apicibus acutis, 6–9 × 1.5 μ; paraphyses filiformes.

Ad caules vetustas *Delphinii* sp., Boulder Lake Trail, 28 Maii, 1939, Smith No. *13800*, **Typus.**

Apothecia gregarious, stipitate, without stroma, 0.5 mm. in diam., soft waxy, remaining cup-shaped with erect margin, inrolled when dry, "pale olive buff" when fresh, drying maize yellow; stipe smooth, 200–300 µ long by 150–200 µ wide, concolorous with the apothecium, composed of fine, rigid, parallel hyphae, expanding radially into the cup, exciple overcast with subglobose, honey-colored cell-like particles arranged in groups simulating triangular scales, 35–40 µ deep and as broad, producing a delicate floccose appearance, scales at margin of apothecia giving a crenate edge; hypothecium composed of fine, colorless interwoven hyphae; asci cylindric, 70–80 × 6–7 µ, eight-spored, pore turning blue with iodine; spores cylindric, with ends somewhat pointed, hyaline, one-celled, 6–9 × 1.5 µ; paraphyses filiform.

PROPOLIS FAGINEA (Schr.) Karst. Myc. Fenn. 1: 244. 1869–1870.

On conifer, Lake Crescent, Sept. 19, 1935, (*2278*); on *Lonicera,* Cape Flattery, May 27, 1939, (*13790*); on madrone, June 2, 1939, (*13986, 13980*); on fir, June 15, 1939, (*14378*); on madrone, June 15, 1939, (*14393*); on conifer, Heart O' Hills, June 19, 1939, (*14462*).

PROPOLIS LEONIA var. WEIRIANA Sacc. Nuovo Giorn. Bot. It. v. XXVII, p. 79. 1920.

The variety was described from material collected at Spokane, Washington, by J. R. Weir, and is distinguished from the typical variety by the large spores and the pale color of the apothecia.

On *Alnus* sp., Lake Crescent, June 15, 1939, (*14377*).

PSEUDOCOLLEMA CARTILAGINEUM Kanouse and Smith. Mycologia 32: 758. 1940.

On a heap of mouse dung, Deer Lake , July 10, 1939, (*14992*).

PSEUDOPLECTANIA NIGRELLA (Fr.) Fuck. Symb. Myc. p. 324. 1869–1870.

On dead wood in a swamp, Kalaloch, April 27, 1939, (*1257*); on soil, Hoh River, May 7, 1939, (*13216*); on moss on a rock, Jackson Guard Station, May 13, 1939, (*13396*); on decayed coniferous wood, Lower Hoh River, May 18, 1939, (*13546*).

PYRENOPEZIZA RUBI (Fr.) Rehm (1887–1896), p. 611. 1892.

A distinctive feature of this species is the dark speckled appearance of the exciple. The outermost layer is decorated with clumps of small, subspherical cells which resemble bunches of myxomycete spores. The hymenium is white to translucent gray. The asci measure 40–50 × 7 μ and the pore turns blue with iodine. The spores measure 9–10 × 1.5–2.5 μ.

On canes of *Rubus spectabilis* Pursh, Joyce, June 9, 1939, (*14226*); Lake Crescent, June 13, 1939, (*14356, 14346*).

PYRONEMA OMPHALODES (Fr.) Fuck. Symb. Myc. p. 324. 1869–1870; Seaver, p. 109. 1928.

On burned soil, Olympic Hot Springs, May 28, 1939, (*13806*).

RHIZINA INFLATA Karst. Act. Fauna Fl. 2: 112. 1885; Seaver, p. 215. 1928.

On burned ground at base of cedar stumps, Lake Quinault, Oct. 24, 1925, collected by C. A. Brown; on burned ground, Mora, May 31, 1939, (*13934*).

RHIZOPODELLA MELASTOMA (Fr.) Richon. Catal. Rais. etc., Soc. Sci. et Arts, Vitry-le-François, XV, p. 191. 1889.

Lake Ozette, May 15, 1939, (*13420*); Lake Crescent, June 2, 1939, (*13988*); Lake Crescent, June 4. 1939, (*14065*); Mt. Angeles, June 28, 1939, (*14676*); Lake Angeles Trail, Sept. 19, 1941, (*17002*).

This fungus has been reported under several names as is shown by the lengthy synonymy given by Seaver (1928) under the name *Bulgaria melastoma* (Sow.) Seaver. He and others recognize that it is neither a true *Bulgaria* nor a good *Urnula*. The nature of the mycelial structure of the apothecia removes it from both of these genera. Richon (l.c.) raised Cooke's subgenus *Rhizopodella* to the status of a genus to accommodate Sowerby's species *Peziza melastoma*. Seaver (l.c.) did not mention Richon's disposition of the species. In correspondence with Nannfeldt about this species we find that we agree that Richon's position is the acceptable one to follow. Nannfeldt has in preparation a paper upon the genus *Urnula* in which he proposes to clarify this situation.

Le Gal (1946) has investigated the manner of dehiscence in the asci of this species and has concluded that it belongs in the group Suboperculati of Discomycetes which she classifies as intermediate between Operculates and Inoperculates.

RHYTISMA PUNCTATUM Fr. Syst. Myc. 2: 696. 1823; Rehm (1887–1896), p. 83. 1888.

This species is distinguished from *R. acerinum* by its smaller asci and spores. The spores measure 40–50 × 7.5 μ which is about one half the length of those in *R. salicinum* Fr.

On leaves of *Acer macrophyllum,* Lake Crescent, June 2, 1939, (*13982*).

Rutstroemia microspora sp. nov. (FIGS. 33–35)

Apothecia solitaria ad gregaria, stipitata, ex stromate nigrum lenticulare oriunda; stroma 2 mm. in diam., in ligno putrido decorticato formatum, discus ad 9 mm., in sicco planus remanens, pallide ochraceus, in sicco brunneus; stipes ad 2.5 mm. longus, levis, albus, rugosus brunneusque in sicco; hypothecium a duobus stratis distinctis efformatum; asci cylindracei, 75–80 × 5–5.5 μ; sporae forma grani Tritici, 7–9 × 3–4 μ, hyalinae, unicellulae, biguttulatae, guttulae ad apices; paraphyses infrequentes, filiformes.

Ad ramulum vetustum, Forks, Washington, 29 Maii, 1939, Smith No. *13942,* **Typus.**

Apothecia solitary to gregarious, stipitate, arising from a black lens-shaped stroma; stroma 2 mm. in diam., formed in decayed decorticated wood, easily separable from the woody matrix, disk expanding up to 9 mm., remaining nearly flat on drying, "light buff" when fresh, drying brown; stipe up to 2.5 mm. in length, not enlarged at the point of insertion with the disk, smooth, drying wrinkled, white when fresh, drying brown, shining; hypothecium composed of two layers, a thin layer immediately beneath the hymenium composed of narrow, interwoven hyphae, the layer immediately beneath made of pseudoparenchymatic hyphae so densely packed that the individual cell-like portions cannot be distinguished; asci cylindric, 75–80 × 5–5.5 μ, eight-spored, the pore faintly blue with iodine; spores wheat-kernel in shape, 7–9 × 3–4 μ, hyaline, one-celled, a small oil drop located in each end; paraphyses scarce, filiform.

The presence of a stroma and woody substratum are two of the requisite characters for placing this fungus in the genus *Rutstroemia* as interpreted by White (1941). The firm texture is like that commonly found in species of *Rutstroemia.* The small asci and small spores distinguish it from other species described on wood substrata.

Sarcosphaera amplissima (Fr.) comb. nov. *Peziza amplissima* Fr. Summa veg. Scand. p. 349. 1849; Seaver (1942. pl. 46, as *Sarcosphaera coronaria*).

This species is known under several names, most common of which is *Sarcosphaera coronaria* (Fr.) Schroet. According to the International Rules of Nomenclature the Friesian name *Peziza amplissima* must be recognized and the valid name then becomes *Sarcosphaera amplissima.*

On ground , Mt. Angeles Trail, June 19, 1939, (*14441*) ; Sol Duc Trail, 3,000 ft. elev., June 20, 1939, (*14469*) ; Deer Lake Trail, June 24, 1939, (*14619*) ; Lake Angeles Trail, June 25, 1939, (*14646*).

SCLEROTINIA URNULA (Weinm.) Rehm, p. 804. 1893.

On fruits of *Vaccinum* sp., Kalaloch, May 10, 1939, (*13300, 13303*).

SPATHULARIA FLAVIDA Fr. Summa veg. Scand. p. 347. 1849.

Under fir, Joyce, Oct. 28, 1935, (*3384*) ; Crescent Beach, June 21, 1939, (*14521*). Identifications made by E. B. Mains.

STICTIS RADIATA (Pers.) Fr. Syst. Myc. 2: 194. 1923.

On *Lonicera* sp., Cape Flattery, May 27, 1939, (*13791*) ; on madrone, Lake Crescent, May 29, 1939, (*13853, 13855*) ; on *Sambucus* sp., Forks, May 31, 1939, (*13939*) ; on sticks, Lake Crescent, June 1, 1939, (*14370*) ; on sticks, Lake Crescent, June 3, 1939, (*14021*) ; on sticks, Olympic Hot Springs, June 5, 1939, (*14093*).

STICTIS SERPENTARIA E. & E. Tor. Bot. Cl. 24: 469. 1871.

This species was originally found in Washington on *Salix* s Our plants agree well with Ellis' description. The spores a loosely coiled in a serpentine manner when they become free fro the asci.

On *Sambucus callicarpa* Greene, Port Ludlow, May 30, 193 (*13904*).

TAPESIA CINERELLA Rehm. Hedw. 21: 102. 1882.

On stems of *Gaultheria shallon* Pursh, Mora, May 22, 193 (*13677*).

TAPESINA GRISEO-VITELLINUM (Fuck.) v. Höhnel. Frag. zu Mykol. Sitzb. der Akad. der Wissensch. Math.-Nat. Kl. Ab 132. Bd. 4–8 Heft. 1923.

V. Höhnel emended the genus *Tapesina* and made Fuckel *Velutaria griseo-vitellinum* the type of the genus. The fungus characterized by a yellow-green color of the hymenium and a dar brownish exterior. The spores are four-celled.

On *Alnus* sp., Kalaloch, April 29, 1939, (*13008*); on twigs hardwood, Lake Crescent, June 15, 1939, (*14390*).

TRYBLIDARIA WASHINGTONENSIS Kanouse. Mycologia 33: 46 1941.

On decorticate wood of *Chamaecyparis nootkatensis* and upon foliose lichen (*Physia?*) growing upon the wood. Sol Duc Pa Trail, June 26, 1939, (*14486, 14487*).

UNGUICULARIA SCRUPULOSA (Karst.) v. Höhnel. Mitt. Bot. Ins Tech. Hochsch. Wien. 5. 1928.

This is a minute white, cup-shaped fungus, that grows on o wood. The margin of the cup is edged with hairs which a glistening and have a septum only at the base. Asci are 60–65 8 μ. The spores measure 9 × 3–4 μ. Both asci and spores a remarkably large for such small apothecia.

On old wood, Hoh River, May 13, 1939, (*13391*).

VELUTARIA RUFO-OLIVACEA (Pers. ex Fr.) Fuck. Symb. Myc. p. 300. 1869–1870.

On old stems, Clearwater River, May 9, 1939, (*13280*).

VERPA CONICA Fr. Syst. Myc. 2: 24. 1823; Seaver, p. 245. 1928.

On ground under *Alnus* sp., Hoh River, May 7, 1939, (*13187*); on soil near snow bank, 4,800 ft. elev., Boulder Lake Trail, May 22, 1939, (*13823*).

VIBRISSEA TRUNCORUM Fr. Syst. Myc. 2: 31. 1823; Durand, p. 452. 1908.

Kalaloch, May 2, 1939, (*13067*); on conifer sticks in stream, Hoh River, May 18, 1939, (*13524, 13530*); Forks, May 22, 1939, (*13680*); Sol Duc Park Trail, June 20, 1939, (*14491*). Identified by E. B. Mains.

XYLOGRAPHA ABIETINA (Pers.) Zahlb. Catalogus lichenum universalis 2: 151. 1934.

On conifer log, Lake Angeles, June 25, 1939, (*14648*). Identified by M. L. Lohman.

XYLOGRAPHA SPILOMATICA (Anzi) Th. Fries. Lichenog. Scand. 1: 639. 1874.

On dead conifer wood, Deer Lake Trail, June 13, 1939, (*14325*). When this fungus is fresh and moist it is very inconspicuous as it is the exact color of the wood upon which it grows. The asci are large and are thickened greatly at the apices. The opening of the mature asci seems to be caused by a swelling of a substance which, on expansion, tears the ascus open. The hypothecium is composed of small, subspherical, heavy-walled cells. The spores are one-celled and are biseriate. They measure 10–12 × 6–8 μ. The paraphyses form an epithecium.

UNIVERSITY OF MICHIGAN,
ANN ARBOR, MICHIGAN

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EXPLANATION OF FIGURES

FIGS. 1–3. *Ascophanus brunneus;* 1, an ascus and paraphyses; 2, two spores; 3, an apothecium × 5.

FIGS. 4–6. *Belonioscypha miniata;* 4, asci and paraphysis; 5, spores; 6, an apothecium.

FIGS. 7–9. *Discina olympiana;* 7, an ascus; 8, paraphyses; 9, spores.

FIGS. 10–12. *Discinella washingtonensis;* 10, an apothecium × 3; 11, spores; 12, an ascus and a paraphysis.

FIGS. 13–16. *Humaria stellata;* 13, top view of an apothecium; 14, an ascus and 2 paraphyses; 15, two spores; 16, two stellate hairs.

FIGS. 17–19. *Humarina washingtonensis;* 17, an apothecium; 18, an ascus and paraphysis; 19, two spores.

FIGS. 20–23. *Lachnaster miniatus;* 20, a group of hairs; 21, spores; 22, an ascus; 23, a paraphysis.

FIGS. 24–25. *Ombrophila Lysichitonis;* 24, an ascus and paraphysis; 25, spores.

FIGS. 26–29. *Phialea olympiana;* 26, an apothecium; 27, detail of rope-like net on exciple; 28, spores; 29, an ascus and paraphysis.

FIGS. 30–32. *Phialea pallida;* 30, sketch of excipular cells with adherent particles; 31, an ascus and a paraphysis; 32, spores.

FIGS. 33–35. *Rutstroemia microspora;* 33, an apothecium; 34, an ascus and paraphysis; 35, spores.

A NEW SPECIES OF CRISTULARIELLA ASSOCIATED WITH A LEAF SPOT OF MAPLE

ALMA M. WATERMAN AND RUSH P. MARSHALL[1]

(WITH 2 FIGURES)

In the summer of 1941 the writers observed the defoliation of a boxelder (*Acer negundo* L.) on the grounds of the Bartlett Tree Research Laboratories at Stamford, Connecticut. The foliage showed numerous target-like spots (FIG. 1, *A*) bearing very unusual fungus conidiophores. Collections of leaves of sugar maple (*A. saccharum* Marsh.) and sycamore maple (*A. pseudoplatanus* L.) with similar spots and conidiophores have since been received from New York and Pennsylvania.

The distinctive symptom of the disease on all the hosts is the yellowish gray spots, showing a series of light brown concentric rings on the upper leaf surface (FIG. 1, *B*) resulting in the target-like appearance. The spots are marginate, and vary in size, sometimes coalescing over large areas of the leaf surface. They are usually much larger on sugar maple than on the other two hosts On the under surface the spots are brown with no concentric rings On both surfaces of the spots, but more commonly on the lower surface, hyaline conidiophores with pyramidal heads (FIG. 2, *A*) may be present. The heads easily become detached from the stalks (FIG. 2, *B*) and therefore may not be readily observed. A search of mycological literature failed to reveal any description of a similar fungus but it corresponds in many respects morphologically and physiologically with *Cristulariella depraedans* (Cke.) Hoehn. as described by Bowen (1). Since the chief distinction between the two fungi lies in the branching of the conidiophore it

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[1] Associate Pathologist and formerly Pathologist, respectively, Division of Forest Pathology, Bureau of Plant Industry, Soils and Agricultural Engineering, U. S. Department of Agriculture, in coöperation with the Osborn Botanical Laboratory, Yale University, New Haven, Conn.

seems advisable to emend the description of the monotypic genus *Cristulariella* to include both fungi and to describe the fungus with the pyramidal heads as a new species of that genus.[2] For the purpose of comparison of the two species an emended description of *C. depraedans*, corresponding with the studies of this species by von Hoehnel (2) and Bowen (1), is also given.

CRISTULARIELLA Hoehn. (Emended description)

Hyphae steriles repentes, hyalinae vel subhyalinae; hyphae fertiles hyalinae, assurgentes, septatae, solitariae, in capitulum compactum, multiramosum, cristulatum, globosum vel pyramidale terminantes; rami dense compacti, clavati vel subglobosi, unicellulares, repetite di- vel trichotome ramosi, ex apice inflato-globoso vel per partem superiorem hyphae fertilis in forma pyramidis orientes; conidia solitaria ad apices ramulorum ultimorum, globosa, hyalina, continua.

Sterile hyphae decumbent, hyaline or subhyaline; fertile hyphae hyaline, ascending, septate, solitary, terminating in a compact multibranched, cristulate, globose or pyramidal head; branches densely compact, clavate or subglobose, unicellular, repeatedly di- or trichotomously branched, arising either from an inflated-globose apex or along the upper part of the fertile hypha (conidiophore) in the form of a pyramid; conidia produced singly at the tips of the ultimate branches, globose, hyaline, continuous.

CRISTULARIELLA DEPRAEDANS (Cke.) Hoehn. Akad. der Wiss. Wien. Math.-Nat. Kl. Sitzber. **125** (Abt. 1): 124. 1916. Bowen, Conn. Agr. Exp. Bull. **316**: 635. 1930.

Syn.: *Polyactis depraedans* Cke. Jour. Quek. Micr. Club. S. II, **2**: 141–142. 1885.

Botrytis depraedans Sacc. Sacc. Syll. Fung. **4**: 134. 1886.
Illosporium diedickeanum Sacc. Ann. Mycol. **6**: 563. 1908.

Spots on leaves gray, definite or confluent, nonmarginate, epiphyllous; fertile hyphae amphigenous, usually epiphyllous, solitary, erect, hyaline, 100–270 μ long, 8–16 μ diam., usually 5-septate, terminal cell up to 28 μ wide, rounded with radiating compact branches forming a globose cristulate head, heads 100–150 μ in diam.; branches elliptic-clavate, unicellular, repeatedly di- or trichotomously branched; conidia produced singly at the tips of the ultimate branches, rare, minute, globose, hyaline, continuous, 2–4 μ diam.

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[2] The authors are indebted to Miss Edith K. Cash, Associate Mycologist, Division of Mycology and Disease Survey, Bureau of Plant Industry, Soils and Agricultural Engineering, for suggestions regarding the classification of the species and for assistance in the preparation of the Latin diagnoses.

Habitat: On living leaves of *Acer pseudoplatanus* in England (type of genus) and Germany; of *A. saccharum* and *A. saccharinum* L. in the United States.

Cristulariella pyramidalis sp. nov.

Maculis foliorum amphigenis, flavo-griseis vel fulvis, definitis, marginatis, subinde confluentibus, cuticula epiphylla concentrice elevata; hyphis fertilibus amphigenis, plerumque hypophyllis, hyalinis, solitariis, assurgentibus, 0.5–1 mm. longis, 12–16 μ diam., septatis, subinde ad septa leniter constrictis, parte superiori pyramidiformi, 250–450 μ longa, 80–120 μ diam., e ramis dense compactis composita, apice tenui acutiusculo; ramis compactis, subglobosis, unicellularibus, repetite di- vel trichotome ramosis; conidiis raris, solitariis, ad apices ramulorum ultimorum oriundis, minutis, globosis, hyalinis, continuis, 2–4 μ diam.

Spots on leaves yellowish gray, definite, occasionally confluent, marginate, amphigenous, cuticle of upper surface raised in concentric rings; fertile hyphae amphigenous, usually hypophyllous, hyaline, solitary, ascending, 0.5–1 mm. long, 12–16 μ diam., septate, sometimes slightly constricted at the septa, upper portion branched forming a pyramidal head, heads 250–450 μ long, 80–120 μ diam.; apex of fertile hypha, slender, more or less acute; branches compact, subglobose, repeatedly di- or trichotomously branched; conidia rare, solitary, produced at the tips of the ultimate branches, minute, globose, hyaline, continuous, 2–4 μ diam.

Habitat: on living leaves of *Acer negundo*, *A. saccharum*, and *A. pseudoplatanus* in Connecticut, New York and Pennsylvania.

Type specimen FP96300 on leaves of *A. negundo*, Stamford, Connecticut, collected by R. P. Marshall, July 24, 1941, has been deposited in the Mycological Collections, Plant Industry Station, Beltsville, Maryland; type collection specimens in the herbarium of the New York Botanical Garden, in Farlow Herbarium, Harvard University, Cambridge, Massachusetts, and in the Forest Pathology Laboratory, Bureau of Plant Industry, Soils and Agricultural Engineering, at New Haven, Connecticut. Specimens

FP96301 on *A. saccharum* and FP96302 on *A. pseudoplatanus* are also on file at the Forest Pathology Laboratory at New Haven.

Sections through the spots on which the conidiophores of *Cristulariella pyramidalis* were found showed the presence of a small amount of wide hyaline or subhyaline superficial hyphae on the upper surface from which the occasional conidiophores arose. Strands of narrower hyphae in small amounts were present in the epidermis of both leaf surfaces and occasionally between the mesophyll cells. Most of the epidermal cells of the upper surface were partially decomposed and, below the concentric rings in the cuticle, they were entirely missing with strands of hyphae conspicuous in these areas. The conidiophores found on the lower surface seemed to arise from the hyphae in the epidermis. Small superficial clusters of brown hyphal cells were scattered over the upper leaf surface of the spots but the relation of these to the epidermal hyphae could not be determined.

The slender conidiophores arise at right angles to the leaf surface and vary in height from 0.5 mm. to 1 mm. Each conidiophore is composed of a single septate central hypha, the lower cells of which are of uniform width, but the upper cells are usually of gradually decreasing width, tapering to a more or less acute apex (FIG. 2, *C*). Along the sides of these upper cells arise the characteristic subglobose lobed cells, which, by their continued acropetal growth and formation of di- and trichotomous uniseptate lobes, develop into a pyramidal head. Occasionally non-typical heads are found in which the central hypha has a muticate apex as illustrated by the lower conidiophore in figure 2, *B*, or is pinnate-branched with each lateral branch forming a pyramidal head. The typical heads measure approximately 250–450 μ in length and eventually become detached from the stalk by abstriction at the septum just below the lowest branches (FIG. 2, *B*, *D*). Late in the season the heads become subhyaline or light tan in color and occasionally small globose hyaline spores are produced singly on the tips of the outermost lobes, particularly on those of the lower portion of the head. These spores seem to be rare in nature and are easily detached. Other globose branches at the base of the head sometimes develop long septate branches (FIG. 2, *D*).

In Petri dish cultures on Leonian's medium (3) each spore produced at first a small ovoid cell, somewhat resembling the original spore in size and shape, from which one short germ tube developed but soon ceased to elongate (FIG. 2, *E*). The function of these spores was not determined but it is possible that they are microconidia. When the branched head of the conidiophore or a portion of a head was transferred from a leaf spot to agar, the lobed branches developed hyphae from which a white fluffy aerial mycelium was produced. Within about ten days numerous conidiophores were present among the aerial hyphae, each consisting of a single septate central hypha, much narrower than that produced in nature, bearing short flexuous branches along both sides of the upper cells. Small acrogenous solitary spores of the same size and character as those produced in nature were borne on the central hypha and on each of the branches (FIG. 2, *F*).

When transfers were made to culture tubes or flasks of Leonian's medium, in about two weeks a few small compact masses of hyaline hyphae were formed in the center of the culture on the inoculum block or along the edge of the medium near the glass of the tube or flask, or occasionally sparsely scattered over the surface of the medium. These masses gradually increased in size, with small globules of moisture adhering to the surface, which became brown and finally shining black, and formed definite sclerotia (FIG. 2, *G*). The sclerotia were more or less globose when growing singly, but occasionally several coalesced into knobby clusters. The rind was composed of brown, rather thin-walled palisade-like cells, two or three layers in thickness, covering the entire stroma except where the latter touched the glass. The medulla was white, consisting of wide, rather thick-walled hyphae which were closely interwoven just inside the rind, but more loosely arranged at the center. When first formed the sclerotia adhered rather firmly to the mycelial substrate but as the culture dried out they became easily detached. In some cases the small newly developed sclerotia became entirely overgrown with hyphae among which sporulating conidiophores were produced. The surface of the rind of such sclerotia remained gray because of the presence of the hyphae, but the rind itself was of characteristic texture. Sclerotia were produced only sparingly in all cases and none of them showed any further development.

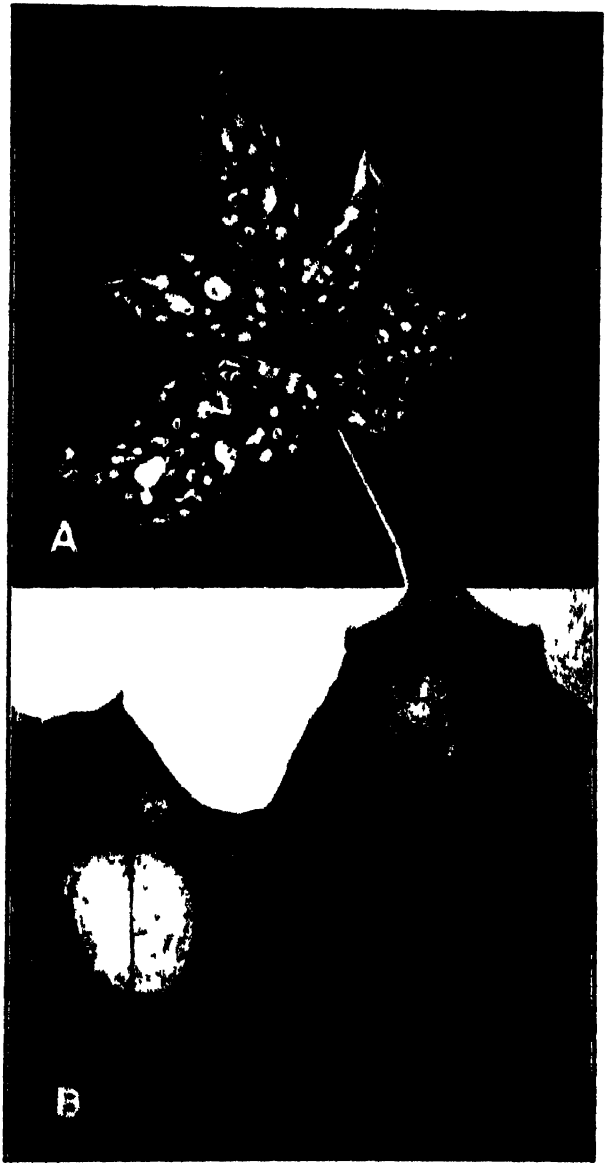

FIG. 1. Target-like leaf spots on which fertile hyphae of *Cristulariella pyramidalis* were found A, boxelder leaf, slightly reduced; B, sugar maple leaf, × 1.5.

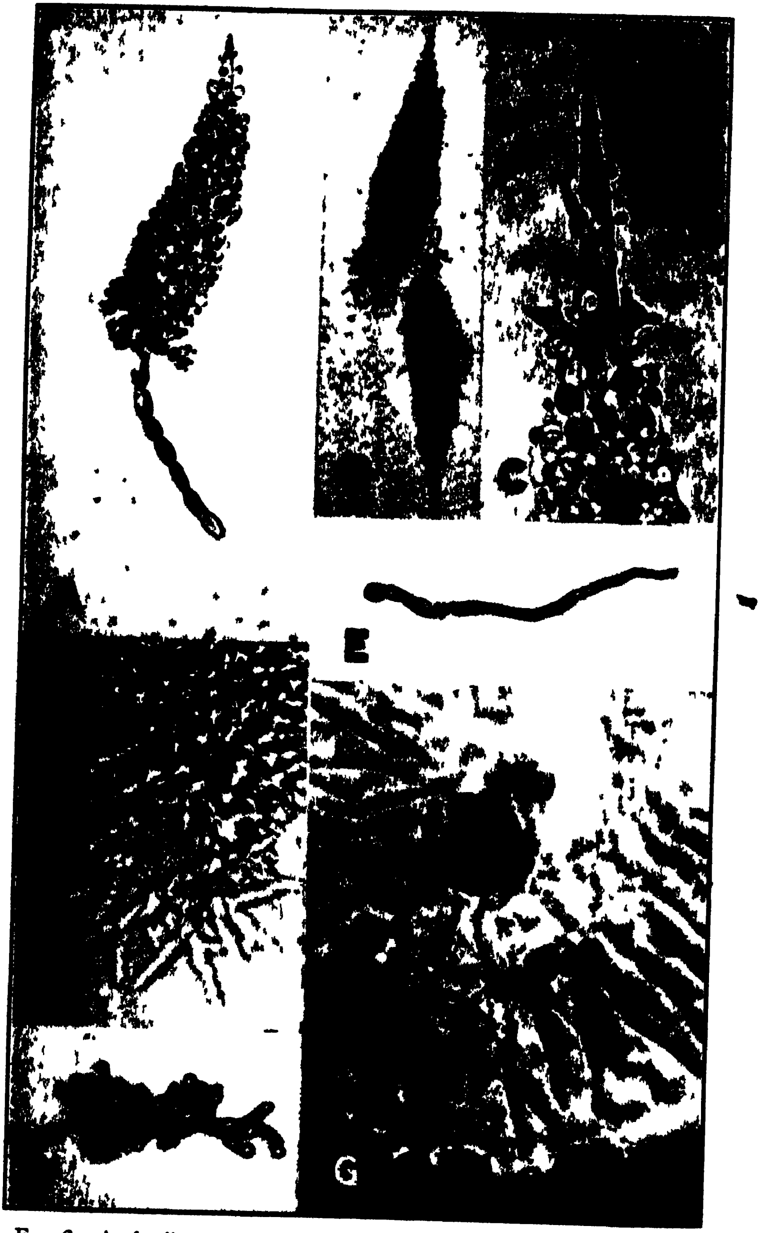

FIG. 2 A, fertile hypha of *Cristulariella pyramidalis* showing branched pyramidal head and septate stalk, × 160. B, heads of fertile hyphae—the

When the agar in the flask cultures was completely overgrown with mycelium and conidiophores the surface of the culture developed a definite convoluted or furrowed appearance (FIG. 2, *G*), which seemed to be characteristic of the species. When an isolate from boxelder and one from sugar maple were grown in the same flask a furrow was formed at first where the mycelia from the two isolates intermingled but the furrow was soon broken by cross furrows until the white surface took on the appearance of one uniform culture. As the cultures aged the mycelium in the flasks became grayish, and that in the test tubes a light tan resembling the color of the conidiophore heads in nature in late summer. The eight-sided crystals reported by Bowen (1) in agar cultures of *Cristulariella depraedans* were produced in great abundance in all cultures of *C. pyramidalis.*

The following summarizes briefly the characteristics of the two species of *Cristulariella* on the hosts and in culture, particularly in regard to the differences between the species:

Cristulariella depraedans. Hosts: *Acer pseudoplatanus, A. saccharum, A. saccharinum.* Leaf spots gray, definite or confluent, non-marginate. Fertile hypha on leaf spot erect, septate, terminal cell rounded with radiating compact branches, repeatedly di- or trichotomously branched, forming a globose cristulate head; in culture usually uniseptate, with globular terminal cell bearing a small loosely compact cluster of basidium-like branches at the tips of which are produced small globose spores 2–3 μ in diameter. Aerial hyphae in culture slow-growing, white, fluffy; an abundance of eight-sided crystals formed in agar media. Black sclerotia produced in culture, at first small, spherical, later merging into a mat.

Cristulariella pyramidalis. Hosts: *Acer negundo, A. pseudoplatanus, A. saccharum.* Leaf spots yellowish gray, definite, sometimes confluent, marginate; cuticle of upper leaf surface of spots slightly raised in brown concentric rings. Fertile hypha on leaf

upper one having been abstricted from the stalk, × 65; C, tip of fertile hypha with di- and trichotomous lobed branches, × 386; D, base of head of fertile hypha with long septate branches, × 386. E, germinating spore, × 386; F, fertile hypha produced in culture, × 386; G, portion of mycelial mat on agar in flask culture, showing surface convolutions and sclerotia, × 1.5.

spot erect, septate, upper portion branched forming a pyramidal head; apex slender, more or less acute, branches compact, repeatedly di- or trichotomously branched; in culture slender, several-septate, with short flexuous basidium-like branches forming an irregular pyramidal head; central hypha and branches producing at the tips small globose spores 2–3 μ in diameter. Aerial hyphae in culture slow-growing, white, fluffy; surface becoming furrowed in older cultures; eight-sided crystals formed in abundance in agar media. Black sclerotia produced in culture small, spherical, solitary or coalescing in small groups.

The parasitism of *Cristulariella pyramidalis* and the relative susceptibility of species of *Acer* to this disease have not been determined. *Acer saccharum* and *A. pseudoplatanus* have been reported as hosts for both species of *Cristulariella*. Pirone (4, p. 251) illustrated a leaf spot on *A. pseudoplatanus* resembling that with which the writers have found *C. pyramidalis* to be associated. He designated it as "bull's eye spot" on several species of maple growing in shady places in the eastern United States and stated that the causal organism had been described as *C. depraedans*. This latter species, however, forms an entirely different type of spot without the distinct bull's eye appearance. It has been adequately described by Bowen (1), who proved the parasitism of *C. depraedans* by inoculations with mycelium and with spore suspensions. The source of inoculum for early spring infection, however, was not determined. No sclerotia of either species of *Cristulariella* have been found as yet on fallen leaves and no ascigerous stage is known. A further study of the life history of the two species is desirable.

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THE RELATION OF THIAMIN TO THE PRODUCTION OF PERITHECIA BY CERATOSTOMELLA FIMBRIATA [1]

H. L. Barnett and Virgil Greene Lilly

It is a well established fact that many fungi are unable to synthesize certain necessary vitamins, or are capable of only limited synthesis. If normal vegetative growth is to result, these vitamins must be supplied by the medium in or on which these fungi grow. In contrast with our knowledge of the dependence upon vitamins for normal vegetative growth, little is known regarding the relation of these vitamins to sexual reproduction in fungi. Robbins and Ma (6) postulated that the formation of sex organs by various vitamin-deficient fungi would be found to be associated with the specific vitamin for which a fungus is deficient. Barnett and Lilly (1) have recently shown that, for *Sordaria fimicola*, a sufficient amount of biotin in the medium is necessary for (a) normal vegetative growth, (b) the production of perithecia and (c) the formation of normal mature ascospores, and that the amount of biotin required increases in the above order. The number of mature ascospores formed by this fungus was directly proportional to the amount (sub-optimal) of biotin added to the medium. Hawker (3), working primarily with *Melanospora destruens*, reported that an exogenous source of biotin was necessary for abundant mycelial growth and that fruiting occurred only on the further addition of thiamin.

Ceratostomella fimbriata (Ellis and Halst.) Elliott was reported by Robbins and Ma (5) to be highly deficient for thiamin and, under their conditions at 20° C., to have lesser deficiencies for biotin and pyridoxine. The effect of these vitamins upon the sexual reproduction of *C. fimbriata* was not reported. In the light of the above-mentioned work with *S. fimicola*, it was believed possible that thiamin might have a direct effect upon the sexual reproduction of *C. fimbriata*. The purpose of this paper is to report the results of investigations to determine the influence of thiamin upon the formation of perithecia by this fungus.

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[1] Published with the approval of the Director of the West Virginia Agricultural Experiment Station as Scientific Paper No. 374.

MATERIALS AND METHODS

The isolate of *C. fimbriata* used throughout these investigations originated from a diseased sweet potato obtained from a local grocery. Perithecia, ascospores and conidia were formed in abundance on two per cent malt extract agar which was used as stock culture medium. Various culture vessels were used, depending upon convenience and the nature of the experiment. In experiments where the weight of the mycelium was desired, 250 ml. Erlenmeyer flasks, previously cleaned with sulfuric acid-dichromate solution and containing 25 ml. of liquid medium, were used. Replicates of eight to twelve flasks were inoculated so that frequent harvests of duplicate cultures could be made at desired intervals. Other experiments were conducted in test tubes or in Petri dishes containing approximately 20 ml. of agar medium.

The basal medium, which has proven very satisfactory for vitamin study in this laboratory, had the following composition:

Glucose	25 g.
Casein hydrolysate equivalent to	2 g. casein
Fumaric acid	1.32 g.
KH_2PO_4	1.0 g.
$MgSO_4 \cdot 7H_2O$	0.5 g.
Na_2CO_3	1.1 g.
Fe^{+++}	0.2 mg.
Zn^{++}	0.2 mg.
Mn^{++}	0.1 mg.
Double distilled water to make	1000 ml.

The details of the preparation of the casein hydrolysate and the medium are described by Leonian and Lilly (4). The basal medium was treated with Norit before adding the minor elements. The pH was adjusted to 6.5 and the desired amounts of thiamin added before autoclaving. After autoclaving the pH was approximately 6.0. For convenience and uniformity throughout the paper, the amounts of vitamins are expressed in terms of micrograms (μg.) per liter. For use in tubes and plates the medium was solidified with agar which had been leached with five per cent pyridine (2). A suspension of ascospores and conidia in distilled water was used as inoculum throughout these investigations. All cultures were incubated at 25 ± 1° C., except in one experiment specifically mentioned in the text.

VITAMIN DEFICIENCY

In testing this isolate of *C. fimbriata* for vitamin deficiencies the amounts of each vitamin per liter of medium were as follows: thiamin, 100 μg.; biotin, 5 μg.; pyridoxine, 100 μg.; inositol, 5000 μg. These vitamins were tested singly and in combination with thiamin. The dry weights expressed in milligrams of mycelium at the end of eleven days of incubation in the various media were as follows: control, 1.6; thiamin, 123; biotin, 0.3; pyridoxine, 0.3; inositol, 0.3; thiamin and pyridoxine, 124; thiamin and inositol, 121; thiamin and biotin, 124; thiamin, pyridoxine and biotin, 120; thiamin, pyridoxine and inositol, 121; thiamin, inositol and biotin, 116; thiamin, pyridoxine, biotin and inositol, 120. Nearly all of the mycelial growth was at the surface of the medium and all cultures containing thiamin were producing perithecia at the end of six days. The weights of all mycelia grown in media containing thiamin, regardless of the presence of other vitamins, were remarkably uniform. The cultures without thiamin made only a trace of growth. The eleven-day period of incubation allowed ample time for perithecia to be formed in all cultures and for the mycelium in liquid media to reach nearly maximum weight. From these results we may conclude that, under the conditions of these experiments, this isolate of *C. fimbriata* is completely deficient for thiamin, and that it shows no deficiency for biotin, pyridoxine or inositol. The deficiency for thiamin alone was also verified at a temperature of 19° C. No perithecia in any stage of development were formed at this temperature up to sixty days.

THE EFFECTS OF VARYING AMOUNTS OF THIAMIN

After the deficiency for thiamin had been established for this isolate, the effects of sub-optimal concentrations of thiamin were studied. Eight lots of liquid media containing varying amounts of thiamin (from 100 to 0.8 μg. per liter) were prepared and a portion of each lot was solidified with agar. The effects of these concentrations of thiamin were observed upon (a) the radial extension of the mycelium on agar, (b) the dry weight of mycelium produced in liquid media, and (c) the formation of perithecia under both conditions. Basic agar medium without added thiamin was used as a control. These cultures were also compared with others on two per cent malt extract agar. Data recorded on eleven-day old cultures are presented in Table I. Perithecia were judged to be present when the perithecial beaks could be seen above the mycelium with the aid of a hand lens. This means that only mature perithecia were recorded. In all cultures where fully formed perithecia were present, ascospores were also being extruded. Since it proved extremely difficult to make counts of perithecia with any degree of accuracy, only an estimate of the comparative abundance of perithecia can be given.

TABLE I

COMPARISON OF RADIAL GROWTH ON AGAR AND DRY WEIGHT OF MYCELIUM PRODUCED IN LIQUID MEDIA CONTAINING VARYING AMOUNTS OF THIAMIN. All cultures eleven days old.

µg. Thiamin per Liter	Liquid Media		Agar Media	
	Mg. Mycelium	Abundance of Perithecia	Diameter of Colony in Mm.	Abundance of Perithecia
none	trace of growth	none	39*	none
0.8	19	none	44	none
1.56	23	none	45	none
3.12	37	few	42	few
6.25	61	numerous	43	several
12.5	90	abundant	43	numerous
25	108	very abundant	46	abundant
50	114	very abundant	50	very abundant
100	111	very abundant	50	very abundant
2% malt extract (no thiamin added)	36	numerous	47	numerous

* The mycelium was so sparse that it was scarcely visible.

After eleven days of incubation the diameter growth of the mycelium was 50, 39 and 47 mm. respectively on medium containing the highest concentration of thiamin, medium with no added thiamin, and on two per cent malt extract agar. On the media containing high thiamin, the mycelial mat was rather thick and dense, and the submerged mycelium was quite dark. On the plates with low thiamin the mycelium was sparse, thin and lighter in color. In the control plates (no added thiamin) the mycelium had extended radially nearly as far as on the media containing thiamin, but it was so sparse that it was scarcely visible. Considering the much greater total growth in the cultures with thiamin, it is surprising that the radial extension on medium without added thiamin was so great. The dry weights of mycelia grown for the same period in liquid media showed only a trace of growth (estimated as 0.5 mg.) in the control, while 111 mg. of mycelium was produced in the flasks containing 100 µg. of thiamin per liter. Below 25 µg. of thiamin, the amount of mycelium produced was in proportion to the amount of thiamin present.

Perithecia were numerous to abundant on all plates containing between 25 to 100 µg. of thiamin per liter, whereas no perithecia were formed when the thiamin concentration was less than 3.12 µg. At the 6.25 µg. concentration the perithecia are clustered near the point of inoculation. The critical concentration required for the production of perithecia on agar medium containing the standard supply of nutrients seemed to be near 3 µg. per liter. There were significantly fewer perithecia produced on two per cent malt extract agar than on the casein-hydrolysate medium containing high concentrations of thiamin. In liquid media the results were very similar, perithecia being formed in the medium containing 3.12 µg. of thiamin.

The amount of thiamin in the medium had no apparent influence upon the abundance of conidia, except in so far as it affected the amount of mycelium produced.

THE EFFECTS OF ADDING THIAMIN TO THIAMIN-STARVED MYCELIUM

The results of the above experiments have raised the question as to whether the failure to produce perithecia in low concentrations of thiamin was due directly to an insufficient supply of thiamin, or whether, because of the limited growth of the mycelium, it lacked sufficient vigor to produce perithecia. In an attempt to answer this question, discs of agar and mycelium were transferred from plates having no thiamin, but containing the full amount of nutrients, to tubes of each of the following: (a) distilled water; (b) distilled water and thiamin; (c) distilled water and purified agar; (d) distilled water, thiamin and purified agar.

Mature perithecia discharging ascospores were formed within six days in all tubes containing thiamin (with the exception of a few in which the inoculum was completely submerged in liquid), whereas no perithecia were developed in any tubes which lacked thiamin. The presence of the agar had no visible effect either upon the slight growth of the mycelium or upon the production of perithecia. This experiment was repeated several times with identical results. The transfer of mycelium grown in liquid medium containing 0.8 μg. of thiamin likewise gave the same results.

Since these four media (mentioned directly above) contained no nutrients, the growth of the mycelium in them was very scanty. Thus, the formation of the perithecia, which sometimes occurred on the new growth of the mycelium, was not conditioned by the vigor of the mycelium. Since the thiamin-starved mycelium produced perithecia when and only when transferred to media high in thiamin, regardless of the amount of nutrients, it seems logical to conclude that the presence of a sufficient amount of thiamin, over and above that required for vegetative growth, is essential to the formation of perithecia.

THE EFFECTS OF VARYING CONCENTRATIONS OF THIAMIN AND NUTRIENTS

To determine whether growth in a medium with a reduced supply of nutrients would influence the production of perithecia, a series of dilutions was prepared from the standard medium minus thiamin. Each of four series contained the undiluted medium and the following dilutions of nutrients: $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$, $\frac{1}{16}$, $\frac{1}{32}$ and $\frac{1}{64}$. Thiamin was then added to the four series at the rates of 100, 6.25, 1.56 and 0.8 μg. per liter. The undiluted standard medium without thiamin served as control. Replicates of eight flasks for each combination of thiamin and nutrients were used. Four harvests of two flasks each from each combination of treatments were made on the fifth, eighth, eleventh and fourteenth days of incubation. The mycelium was removed from the flasks, dried and weighed. Estimates of the relative abundance of perithecia were made on the fifth and eleventh days. The data taken on the eleventh day of incubation are presented in Table II.

TABLE II

DRY WEIGHTS IN MILLIGRAMS AND ESTIMATED ABUNDANCE OF PERITHECIA IN ELEVEN-DAY OLD LIQUID CULTURES WITH VARYING AMOUNTS OF THIAMIN AND NUTRIENTS. Control flasks showed only traces of growth with no perithecia and are not included.

µg. of Thiamin per Liter	Dilution of Nutrients in Medium						
	1/64	1/32	1/16	1/8	1/4	1/2	Undiluted
100	2 ++	3 +++	10 ++++	19 ++++	33 ++++	61 ++++	110 ++++
6.25	2 ++	5 +++	9 ++++	21 ++++	36 ++++	53 ++	59 ++
1.56	2 +	3 +++	10 ++++	11 ++++	17 ++	26 +	30 0
0.8	3 +	6 ++	9 +++	11 +	14 0	17 0	18 0

0 = no perithecia.
+ = less than 20 perithecia per flask.
++ = 20–200 perithecia per flask.
+++ = 200–1000 perithecia per flask.
++++ = more than 1000 perithecia per flask.

In the presence of 100 µg. of thiamin per liter (near the optimum under our conditions), the amount of growth was in direct proportion to the amount of nutrients present. As the amount of thiamin was decreased and the nutrients kept high (undiluted medium to ¼ dilution) there was a significant decrease in the weights of the mycelium produced. However, in a limited supply of nutrients (1/16 to 1/64 dilution) the decrease in the amount of thiamin added had no effect upon the final weight of the mycelium.

Perithecia were formed in all flasks in which the nutrients were greatly reduced (1/8 to 1/64 dilutions) in all concentrations of thiamin, even though some of these cultures produced as little as 2 mg. of mycelium after eleven days of incubation. In a plentiful supply of nutrients (undiluted medium to ¼ dilution), the numbers of perithecia were influenced directly by the amount of thiamin in the medium, none being formed in the presence of 0.8 μg. of thiamin, even though as much as 18 mg. of mycelium per flask was produced. Likewise, cultures in undiluted medium with 1.56 μg. of thiamin produced 30 mg. of mycelium but formed no perithecia.

Mature ascospores were present in all of the above-mentioned cultures which produced perithecia. No condition was found which induced the production of fully formed perithecia without the formation of ascospores. Very small immature perithecia were discovered by microscopic examination in some cultures with very low thiamin and high nutrient content, and in which no mature perithecia developed. Their development was apparently arrested by the lack of sufficient thiamin before the formation of beaks or asci.

We may summarize the conclusions to be drawn from the data presented in Table II as follows: (a) other conditions being equal, the formation of perithecia requires the presence of more thiamin than does mycelial growth; (b) the presence or absence of perithecia is determined by the amount of thiamin in relation to the amount of nutrients in the medium; (c) the abundance of perithecia is influenced by the amount of nutrients and by the amount of thiamin present in the medium.

DISCUSSION

The failure of *C. fimbriata* to form perithecia on media containing sufficient nutrients but very low in thiamin might, on first thought, be interpreted as being due to a general disturbance of some physiological processes, resulting in the inability to produce mycelium vigorous enough to support sexual reproduction. This was the interpretation presented by Robbins and Ma (6) to explain the failure of *C. pluriannulata* to form perithecia on medium lacking thiamin, even though "the fungus grew fairly well on media containing pyridoxine, or both pyridoxine and biotin." These authors report that *C. pluriannulata* is completely deficient for pyridoxine and partially deficient for thiamin.

In the light of the results obtained in the above experiments such an explanation for the failure of *C. fimbriata* to produce perithecia in certain media cannot be justified. Perithecia were formed in flasks of the $\frac{1}{64}$ dilution of nutrients and the 1.56 μg. concentration of thiamin, in which the final weight of mycelium was but 2 mg. No perithecia were present in the undiluted medium with the same amount of thiamin, although 30 mg. of mycelium per flask were produced in eleven days. Likewise, when transfers of thiamin-starved mycelium were made to media high in thiamin but without nutrients, perithecia were formed readily, without significant additional mycelial growth.

We may, therefore, conclude (a) that a minimum amount of thiamin in the medium is essential to the formation of perithecia by *C. fimbriata,* even though lesser amounts of thiamin permit fair mycelial growth, and (b) that the influence of thiamin upon the formation of perithecia appears to be direct, rather than acting through the general disturbance of the metabolism of this fungus. Whether perithecia will be formed on a certain medium is determined (other conditions being favorable) by the amount of thiamin relative to the amount of nutrients in the medium. The abundance of perithecia is conditioned both by the amount of thiamin and the amount of nutrients. The directness of the effect of thiamin is still open for discussion, since we know too little about the metabolic processes in fungi. However, it is clear that sub-optimal concentrations of thiamin cause a greater and more direct effect upon sexual reproduction than upon vegetative growth or the formation of conidia.

The conclusions reached regarding the relation of thiamin to the production of perithecia by *C. fimbriata* are strikingly similar to those previously reported (1) with regard to the relation of biotin to sexual reproduction of *Sordaria fimicola.* This suggests the possibility that perhaps these general conclusions apply equally well to other fungi deficient for these or other vitamins. Further investigations along this line are underway.

SUMMARY

The isolate of *C. fimbriata* used throughout these experiments was found to be completely deficient for thiamin and to show no deficiency for biotin, pyridoxine or inositol.

By keeping the amount of nutrients constant and high, and by reducing the amount of thiamin added to the medium, the formation of perithecia was inhibited.

The dry weight of mycelium produced in liquid media with varying thiamin content is compared with the diameter growth on the same media solidified with purified agar. The effects of these media upon the formation of perithecia are also given.

Thiamin-starved mycelium formed perithecia when and only when transferred to distilled water (or distilled water and agar) plus thiamin. Distilled water without thiamin was without effect.

Evidence is presented which leads to the conclusion that sexual reproduction occurs only when the ratio of thiamin to the amount of nutrients in the medium is relatively high.

DEPARTMENT OF PLANT PATHOLOGY
AND BACTERIOLOGY,
WEST VIRGINIA UNIVERSITY

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·TRICHOMONASCUS, A NEW GENUS AMONG SIMPLE ASCOMYCETES[1]

H. S. JACKSON[2]

(WITH 20 FIGURES)

The fungus to be described was encountered while identifying a miscellaneous collection of Thelephoraceae made during the summer of 1939 in the Timagami Forest Reserve in Northern Ontario. In a crushed mount made from the hymenium of a small collection of *Corticium confluens* Fr., found growing on the bark of a branch of *Abies balsamea,* my attention was attracted to the presence of a simple Ascomycete having such unusual characteristics as to justify special study. This Ascomycete appears to be parasitic on the Corticium and was present in sufficient amount that the essential stages of development could be determined without difficulty. Unfortunately the fungus was discovered several months after the collection had been dried and no study of the nuclear history was possible. Attempts to culture the fungus from this dried material resulted in failure.

In the development of the ascocarp the first stage is the formation of an ellipsoid cell which is cut off from the apex of an upright hyphal carpophore 4–4.5 μ broad, which emerges to the surface of the hymenium of the Corticium. This ellipsoid cell (FIG. 1), when fully formed, is about 15 × 10 μ, and is an ascogonial mother cell, as is shown by its subsequent development. A dome shaped cell is cut off from the apex of this mother cell by the formation of a transverse septum about one fourth the distance from apex to base (FIGS. 2 and 12). If the term "trichogyne," currently in use in connection with descriptions of the sexual structures in Ascomycetes, may be defined as a cell or series of cells cut off from the apex of an ascogonium, then this dome shaped cell may perhaps be properly referred to as a trichogyne. At this stage both cells show a dense granular cytoplasmic content. A slender thread now grows up from the apex of the carpophore just below the ascogonium and is ultimately cut off by a septum close to its point of origin from the stalk cell. This slender thread grows up around the side of the ascogonium and contact is made with the trichogyne at the side (FIGS. 3, 4, 13 and 14). It may grow parallel to the long axis of the ascogonium or slightly oblique to that axis. This thread-like cell, following current usage, may be referred to as an "antheridium."

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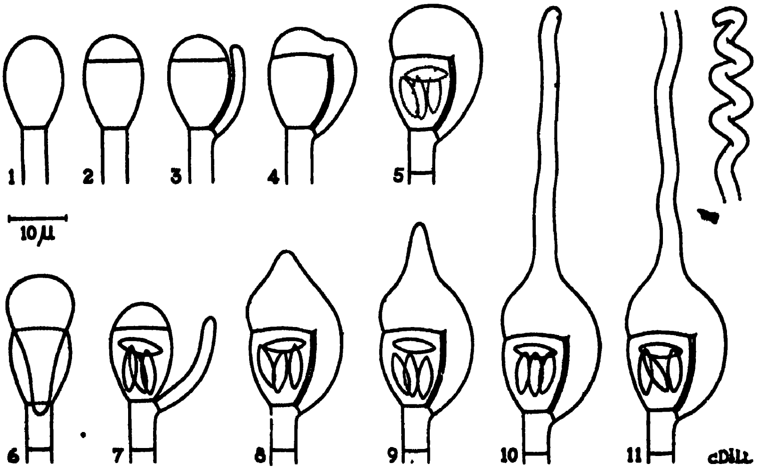
[1] Contribution from Department of Botany, University of Toronto.

[2] The writer is indebted to Miss Margaret Thomson who supplied the Latin diagnosis and to Miss Charlotte Dill for the preparation of the diagrams for figures 1–11.



FIGS. 1–11. *Trichomonascus mycophagus*, diagrams of stages in development. Explanation in text.

Whether or not the initial contact is by a narrowed point at the apex of the antheridial thread could not be determined with certainty. It is clear that in most cases observed the apex of the antheridium appears to be fused with the trichogyne for its whole width and in fact soon begins to broaden out at the apex as will be described below. In some of the cases observed at this stage the contents of the antheridium and trichogyne stain very lightly whereas the ascogonial cell shows deeply stained granular contents. If a true fertilization takes place in this organism by the passage of a nucleus or nuclei from the antheridium through the trichogyne to the ascogonium it would seem probable that it had already occurred in such cases.

Following this stage what would appear to be a unique and unexpected development takes place. The trichogyne together with the antheridial branch begin to enlarge. This process of enlargement takes place as indicated in figures 4–6, 8–11, 14–17. The antheridial branch is at first a slender thread of equal diameter, about 2 μ, throughout its length. After contact is made with the trichogyne, the apex soon begins to broaden out until the two cells appear to develop as one structure. Figures 4 and 5 show the broadened antheridium in side view and figure 6 in face view. At this stage a papilla begins to develop at the apex of the trichogyne (FIGS. 8, 9 and 15) and gradually develops into a long slender thread-like extension which becomes regularly coiled toward the apex (FIGS. 10 and 11, 16–18). This extension may reach 60–75 μ in length and is about 2 μ in diameter.

At any stage after figure 4 evidence that spores are beginning to develop in the ascogenous cell may be observed. The ascogenous cell thus functions directly as an ascus and does not appear to enlarge appreciably after the stage shown in figure 2. The spores are usually quite well developed at the stages shown in figures 8 and 9. Four spores are usually formed and one commonly finds three of them placed more or less lengthwise and the other above at right angles to the long axis of the fructification. The spores are narrowly ellipsoid, 7–8 μ × 3 μ, with smooth colorless walls. The total length of the mature ascocarp, from the base of the ascus to the tip of the elongated trichogyne, is 70–85 μ. Since the ascogonium does not appear to enlarge appreciably from the time the trichogyne is cut off (FIG. 2) till the ascus is mature, and since the antheridial branch broadens out considerably, the mature ascocarp appears laterally compressed when seen from a position in which the antheridial branch is in face view (FIGS. 6 and 19).

Beginning at the stage shown in figure 8 there appears to be an irregular internal thickening in the wall of the upper part of the antheridial branch and around the base of the elongated trichogyne. This is not shown in the diagrams but is brought out in the microphotographs.

When the antheridial branch fails to make contact with the trichogyne there is no further development of the latter (FIG. 7), which suggests that the cytoplasmic connection which furnishes the food material for the development of the trichogyne is through the antheridial branch rather than through the ascogonium. In such cases however the ascus develops ascospores perhaps parthenogenetically, as is not uncommon among lower ascomycetes that are homothallic. A small amount of cytoplasm is apparently present in the developmental stages of the antheridium and trichogyne (FIGS. 8 and 9) as shown by a light staining of the contents.

DIAGNOSIS

Trichomonascus gen. nov.

Ascocarpa terminalis in cylindrata carpophora nata, ex ascogonio quod pro asco stat et ex antheridio trichogynoque quae alterum cum altero juncta extendunt constata; trichogynum postremo longa cylindrata filo similis extensio, in apice in spiram contorquens.

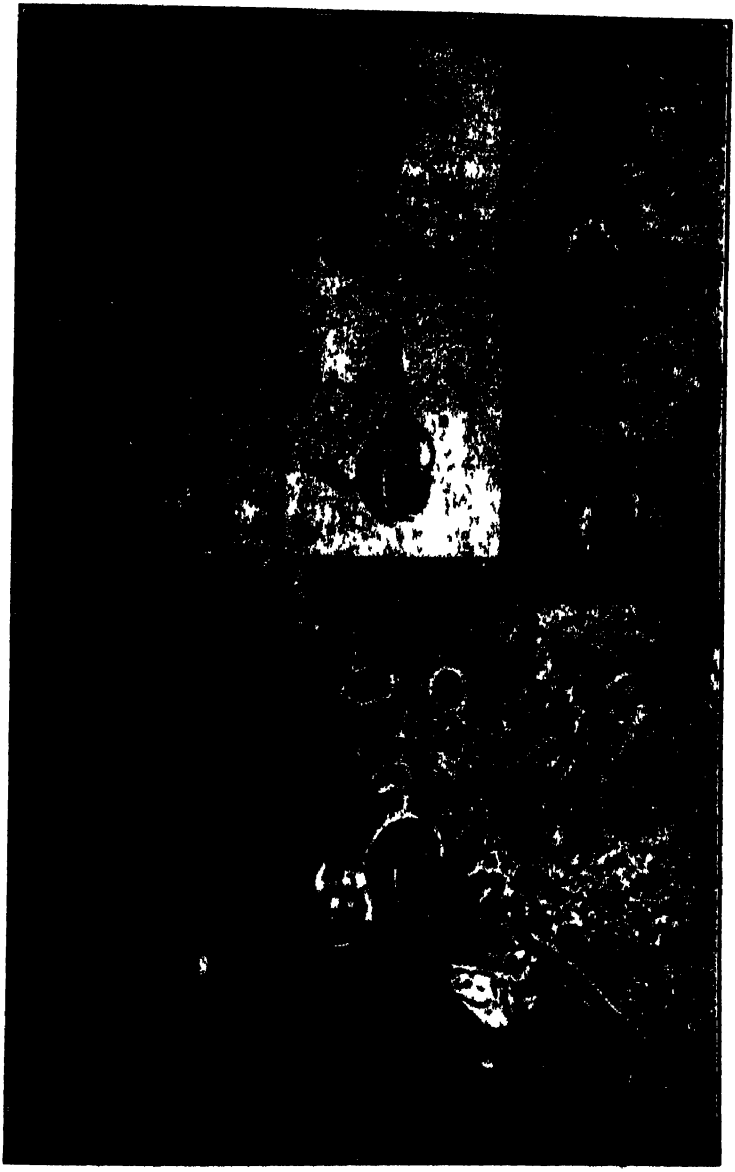
Trichomonascus mycophagus sp. nov.

Ascocarpa terminalis 4–4.5 μ lata in cylindrata carpophora nata; ascogonii materna cella 15 × 10 μ ellipsoida; ascogonium, cella ellipsoida, 10 × 10 μ magnum, non crescens; trichogynum primo cella hemisphaeroida, ex apice ascogonii cellae maternae abruptum; antheridium, gracilis hypha, 2 μ latum, ex apice carpophorae infra ascogonium natum, trichogyno se jungens; his junctis, et antheridium apice latius et densium et trichogynum in apice latius, gracile cylindratum filum, 60–75 × 2 μ magnum, supra in spiram contortum, fiunt; ascus, ascogonium ipsum non mutatum in quo sunt quattuor ellipsoidae aut subfusoidae, hyalinae, 7–8 × 3 μ magnae, muris glabris sporae.

In *Corticio confluente* Fr., in cortice mortuo inferioris rami *Abietis balsameae*, "Bear Island" apud Lacum Timagami invenitur; Aug. 24, 1939. H. S. Jackson TRT *21820*, (**typus**).

DISCUSSION

One of the most intriguing characteristics of Trichomonascus is the subsequent development of the simple dome shaped trichogyne, after it would appear to have served its function, into a structure reminiscent of a more orthodox trichogyne such as occurs in the Florideae and higher Ascomycetes having spermatial (microconidial) fertilization. Shall we dismiss this structural resemblance to a trichogyne as a development having to do with some special



FIGS. 12–20. *Trichomonascus mycophagus*, microphotographs of stages in development. Explanation in text. Extraneous material is of *Corticium confluens*.

method of dissemination of the ascocarp as a whole, or a mechanism having to do with spore dissemination, or is it possible that some phylogenetic significance may be attached to this peculiar development? To those who are not fully convinced of the monophyletic origin of the higher fungi and who consider that it is not impossible that the microconidial or spermatial type of fertilization may be the primitive type of sexuality in the Ascomycetes, Trichomonascus will serve as a new basis for speculation.

While, unfortunately, nothing is known with reference to the nuclear history, if we may judge from the morphology and development as described, Trichomonascus is probably homothallic.

Although I do not wish to enter into a lengthy speculative discussion, a few general remarks on homothallism may not be out of place. I would define true homothallism as that condition among lower organisms in which the full sexual or nuclear cycle may be carried out in a single thallus from an originally uninucleate spore. Such a form is obviously homozygous. Even should gametic union and meiosis occur, the two sets of chromosomes which come together in the zygote would be identical. The occurrence of homothallism in an organism having a highly developed sexual mechanism is strongly suggestive that the condition is derived. The evolutionary development of highly differentiated sexual structures is not to be expected in organisms in which there is no provision for cross fertility. I would therefore consider that in any group showing highly developed sexual structures, or one in which a sexually complete nuclear history occurred in the absence of specialized structures (as for example in the mushrooms), heterothallism is the primitive condition and homothallism derived. It seems reasonable also to suggest that a sexual process involving any method of gametic union would not be expected to become a fixed habit among primitive organisms unless accompanied by a provision for hybridity. This provision for hybridity is the phenomenon we label "heterothallism." The condition which preceded it in the evolutionary development of sexuality in lower organisms was not "homothallism" but sexlessness. Homothallism is a condition of degenerate sexuality. If these suggestions are anywhere near the truth then it follows that great caution should be exercised in basing discussions of phylogeny or interrelationships on homothallic species.

If this general viewpoint may be accepted as reasonable, then it would seem possible that homothallic forms might be derived from heterothallic lines at various times and at different levels in the progressive evolution of the latter. While such homothallic forms would be derived they may not necessarily be recent. Should such forms be segregated early in the evolutionary development of a group and survive to the present day, being homozygous, they might be expected to change but little and so might retain certain primitive characters.

Possibly Trichomonascus is such a relic form and the elongated coiled structure which ultimately develops from the small dome shaped trichogyne cell may represent a true trichogyne which, in the parent heterothallic form from which it was derived, functioned to receive spermatia. This suggestion would make necessary the assumption, as has been suggested by others, that the sexual process involving an "antheridium" in the Ascomycetes is a substitute one for a spermatial type of sexuality and hence of secondary development.

Many such homothallic forms derived early in the evolutionary history of a group would presumably not survive and the few that remain today, and which have so far been discovered, might be expected to appear as isolated, apparently unrelated forms, difficult to fit into a more or less muddled man-made classification.

RELATIONSHIP

In any case the relationship of Trichomonascus to other simple Ascomycetes is not at all clear. The presence of a trichogyne suggests a relationship higher than the Gymnoascaceae. The fact that the ascogonium functions directly as an ascus suggests a lower position. However, the presence of the trichogyne seems the more important character and for the present Trichomonascus may be assigned tentatively as a simple member of the Aspergillaceae. To make a new family for this organism at this time, in view of our inadequate knowledge of the lower Ascomycetes in general, would seem to serve no useful purpose.

THE DUAL PHENOMENON IN THE DERMATOPHYTES

STEPHEN WILHELM [1]

(WITH 2 FIGURES)

Two factors have been responsible mainly for the illogical species concept applied to the dermatophytes. These are (a) failure to take full cognizance of the phenomenon of variation displayed by most species of dermatophytes in laboratory culture, and (b) the naming of species on the basis of gross cultural characteristics on standard media. The range of variation members of a single imperfect species may show, when subjected to single spore analysis, has been demonstrated fully in only a few cases. In the genus *Fusarium*, Snyder and Hansen (12) have shown that the progeny of a single spore culture may show such wide variation as to fall into several species and even sub-sections of the genus as it was formerly constituted. Emmons (2, 3) reported on variation of this nature in *Achorion gypseum* and pointed out that the present system of classification permits the raising of cultural variants to species rank.

Prolonged cultivation in the laboratory induces in many species of dermatophytes an abrupt change in type of growth, known to medical mycologists as pleomorphic overgrowth. This pleomorphic growth apparently arises in response to physiological aging, usually appearing first as white, fluffy tufts at the center or edge of a colony. Often it grows over and obscures the original culture. Medical mycologists frequently refer to this phenomenon as a form of degeneration.

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[1] The author wishes to express his gratitude to Colonel Hugh W. Mahon, Chief of the Laboratory Service, Fitzsimons General Hospital, Denver, Colorado, for permission to undertake this study while in the Army, and to Drs. H. N. Hansen and William C. Snyder, Division of Plant Pathology, University of California, Berkeley, California, under whose direction the study was continued.

Slight changes in the composition of media and changes in environmental factors, especially light and temperature, also are known to cause pronounced variation in gross colony characteristics and in spore size of dermatophytes and other imperfect fungi (14, 16, 17). These types of variation are usually of a transitory nature.

Finally, a species may be composed of a large number of culturally distinct ecological or geographical races. This is true undoubtedly to a greater or lesser degree in all fungi, and has been demonstrated by Hansen (5) in *Phoma terrestris* Hans., *Verticillium albo-atrum* Rke. and Bert., *Botrytis cinerea* Pers., and in members of other form genera.

In this study, twelve isolates of *Epidermophyton floccosum* (Harz) Langeron and Milochevitch and four of *Trichophyton gypseum* Bodin[2] were subjected to single spore analysis through five culture series, and the variation recorded by photograph. A slight modification of the technique of Hansen and Smith (7) for making single spore cultures was employed. The modification consisted of using potato dextrose agar in the place of Czapek's medium for the dilution plates, and of transplanting the sporelings with a small piece of agar to the slants. All cultures were made on potato dextrose agar slants in 1 × 8 inch test tubes, approximately 20 cc. of medium per tube, and were illuminated with indirect daylight from a large northeast window. For comparative purposes some series were duplicated on potato dextrose peptone and on Sabouraud's glucose agars. Because of the paucity of macroconidia in old cultures of *E. floccosum*, chlamydospores as well as macroconidia were used for the single spore cultures; only single celled chlamydospores, however, were selected for transfer. Potato dextrose agar was found to be a very satisfactory medium for both isolating and maintaining these fungi in culture.

The results of single spore analyses of the isolates mentioned above have shown that these dermatophytes are dual, that is, composed of two distinct constituents associated together in culture, one producing conidia in abundance but relatively scant mycelium, designated as the *C* or conidial constituent, the other producing fewer conidia and more abundant mycelium, designated as the *M* or mycelial constituent. This is the dual phenomenon which was reported by Hansen in 1938, and shown to occur in many imperfect fungi. The *M* type of these dermatophytes, as in other imperfect fungi, appears to arise as a mutation in old cultures of the *C* type, even though the culture is started from a single conidium. General reference to the work of Hansen, Snyder and Smith (5, 6, 7, 8, 13) on the dual phenomenon is made at this time. These authors discuss in considerable detail the occurrence in nature, the biological significance, and bearing on the species concept of this interesting phenomenon.

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[2] *Trichophyton gypseum* Bodin has been relegated to synonymy with *T. mentagrophytes* (Robin) Blanchard. In Conant, G., *et al.*, Manual of Clinical Mycology, 1946, W. B. Saunders Co., Phil., but is employed here because of widespread usage.

The sharp contrast in cultural characteristics between *C* and *M* constituents of *T. gypseum* is shown in figure 1, *A*. These distinctions were maintained on potato dextrose peptone, and on Sabouraud's glucose agars, as is shown in figure 1, *B*, but the variation attendant upon changes in medium is striking. According to the system of classification of Conant and his colleagues (1), both *C* and *M* constituents of this one isolate of *T. gypseum* on potato dextrose peptone agar would fall into the crateriform group, *C* being raised and *M* sunken in the center. The *M* constituent on Sabouraud's glucose agar answers to the description of *T. interdigitale* Priestley, now considered synonymous with *T. gypseum*, and the *C* constituent on potato dextrose agar conforms to the asteroid type of *T. gypseum*. This evidence supports the kind of synonymy employed by Conant *et al.* but the inadvisability of dividing the genus *Trichophyton* into groups based on cultural characteristics on standard media becomes apparent.

In addition to segregation into distinct *C* and *M* constituents, *E. floccosum* gave rise to many forms culturally intermediate between *C* and *M*. In this fungus, the *C* and *M* types also differ greatly from each other in cultural appearance, the *C* exhibiting the olive green, compact, slow type of growth, the *M*, the white fluffy growth. *C* and *M*, and a number of intermediate types, are shown in figure 2.

These results suggest that in old cultures the mycelium and spores of *E. floccosum* become heterocaryotic with respect to *C* and *M* nuclei, and that the variation exhibited upon single spore analysis results from chance segregations of these nuclear types in the spores at the time they are formed. Earlier evidence of this phenomenon of heterocaryosis has been presented in the outstanding case of *Botrytis cinerea* (7). In *T. gypseum* where cultures were started from single microconidia, which are presumably uninucleate, the chance for nuclear segregation is eliminated largely, and distinct *C* and *M* types only were obtainable. In *E. floccosum*

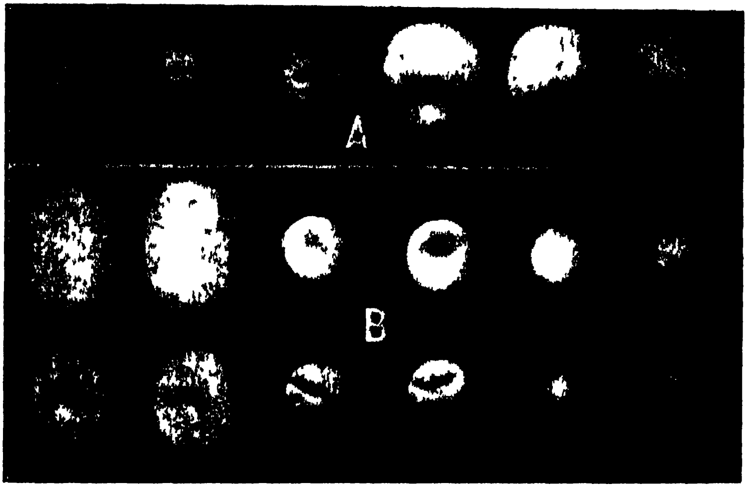

FIG. 1. A. The dual phenomenon in *Trichophyton gypseum*. Left, the *C* constituent; right, the *M* constituent. Cultures are 24 days old on potato dextrose agar. B. *C* and *M* constituents of *Trichophyton gypseum* on Sabouraud's glucose agar, left, potato-dextrose-peptone agar, center; and potato-dextrose agar, right. *C* constituents are in the lower, *M* in the upper row. Cultures are 12 days old on potato dextrose agar

where cultures were begun by single macroconidia or chlamydospores, the latter presumably multinucleate at the time of formation, distinct *C* and *M* types (homotypes) and intermediate *MC* types (heterotypes) were obtainable. Old cultures of the *MC* heterotypes often produced secondary growth from below the parent colony which in general cultural appearance resembled the parent *C* cultures. Of ninety-eight single spore cultures made from such growths appearing in five strains, forty-eight were typical *C*, forty-seven intermediates, and three typical *M* types. This furnishes evidence that chance nuclear segregations in heterocaryotic mycelium may account for this phenomenon, considered analogous to sectoring, as well as for the array of variants obtained upon single spore analysis of old cultures.

In one strain of *T. purpureum* Bang [8] available during this study, the *C* type which at one time produced abundant pigment became overgrown completely by the *M* type and was lost while the culture was in storage. The *M* type which was recovered failed to produce the brilliant red pigment. Rather frequent reference is made in the literature to cultures of *T. purpureum* which lose their ability to form pigment (9, 15), and it seems correct in this case to associate loss in ability to form pigment with the *C* and *M* mutation.

In the great majority of cases the *C* constituent is isolated directly from nature, though from chronic lesions it has been possible to recover both *C* and *M* types of *T. gypseum.*

In stock cultures maintained by mass transfer the *C* constituent frequently is lost. This difficulty may be overcome by making transfers from the extreme edge of the colony before it is completely overgrown, or by starting all cultures from single spores, and selecting out the *C* types. *M* types need not be saved, as they arise repeatedly in the *C*. The *C* type, on the other hand, has never been recovered from *M*.

The literature abounds with references to variation in the dermatophytes for which the dual phenomenon, as we know it today, is the more logical explanation. A few of the outstanding cases will be cited in brief.

Sabouraud (11) in 1929 referred to the phenomenon of pleomorphism as a definite morphological change occurring in old cultures, involving production of a white downy mycelium which can be isolated from the parent form and which does not revert to the parent form even when inoculated into animals and reisolated. He terms the pleomorphic growth a "fixed mutation."

Emmons (2) in 1931 showed that "pleomorphic mycelium" would arise from monospore cultures of both micro and macroconidia of *Achorion gypseum* and that monospore cultures from the pleomorphic growth yielded exactly similar pleomorphic mycelium. He states "just how and where this change takes place, is not clear."

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[8] Relegated to synonymy with *T. rubrum* (Castellani) Sabouraud (*ibid.*) but employed here because of widespread usage.

Gregory (4) considers this pleomorphism an example of the irrevocable mutations or saltations so common in many fungi, rather than a process of gradual degeneration.

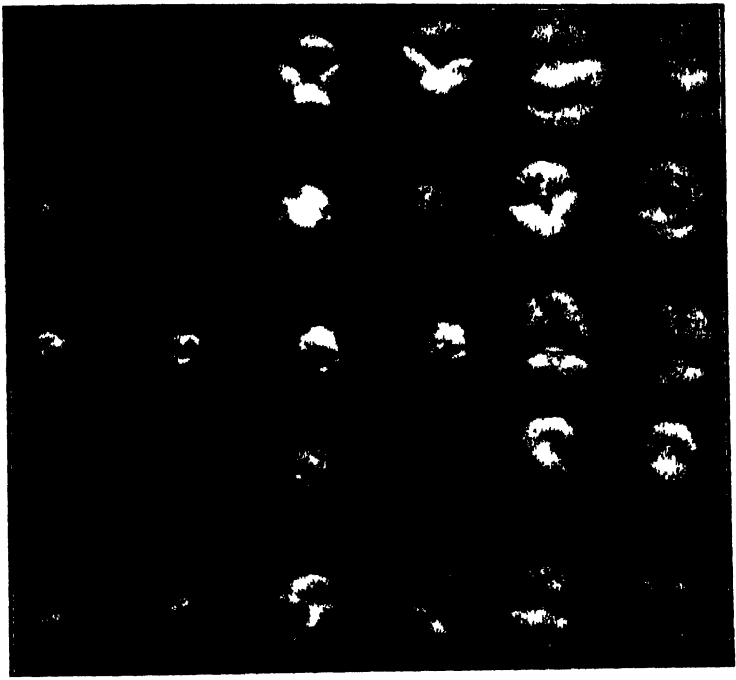

FIG. 2. The dual phenomenon in *Epidermophyton floccosum*, 5 races represented. Left *C* homotypes, center *MC* heterotypes, right *M* homotypes. Cultures 24 days old on potato dextrose agar.

Lewis and Hopper (9) state that with repeated subcultures of occasional strains of some fungi such as *Trichophyton purpureum*, pigment fails to develop in the substrate. They state further that this change is limited to a few strains which have been transferred many times, and that there is a considerable lessening of pigment with the appearance of the pleomorphic overgrowth.

Spring (15) also mentions loss of red coloration of the medium upon single sporing of *T. purpureum*. In her single spore culture studies of *T. interdigitale* she obtained two types, one of which was "highly pleomorphic," and one which retained the original yellow powderiness of the parent culture. In her cross planting studies of a number of representatives of these two types, she obtained colonies which fell into three distinct groups, namely (a) those in which the yellow powderiness persisted, (b) intermediates, in which incipient craters and powderiness were nearly overgrown with a white growth, and (c) those composed entirely of white pleomorphic growth. In the light of the dual phenomenon these three groups are interpreted as follows: group (a) planting of two spores of the *C* type together, group (b) planting of one spore of the *C* and one of the *M* type together, group (c) planting of two spores of the *M* type together. Thus instead of setting forth evidence in favor of heterothallism, as was her intention, Spring presented ample proof of the dual nature of these dermatophytes.

The normal and pleomorphic forms of *T. mentagrophytes* pictured by Robbins and McVeigh (10) may be interpreted respectively as *C* and *M* types.

SUMMARY AND CONCLUSIONS

1. *Trichophyton gypseum* and *Epidermophyton floccosum* are dual fungi, *i.e.*, composed of two distinct constituents associated together in culture, one producing conidia in abundance but relatively scant mycelium, designated as the *C* or conidial constituent, the other producing fewer conidia and more abundant mycelium, designated as the *M* or mycelial constituent.

2. The *M* constituent arises as a mutation in old cultures of the *C* type even though the culture is started from a single conidium. It appears to be genetically stable.

3. In the two species studied, and probably in *T. purpureum* as well, the pleomorphic overgrowth which appears in old cultures resembles the *M* constituent of these fungi.

4. Chance segregation of *M* and *C* nuclei at the time spores are formed on heterocaryotic mycelium of *E. floccosum* provides a mechanism for explaining the variation exhibited upon single spore analysis of old cultures.

5. Similarly, nuclear segregation also appears to be responsible for sectoring.

6. Members of a species may represent culturally distinct races which probably correspond to ecological or geographical variants.

7. In old stock cultures maintained by mass transfer, the *C* type frequently is lost due to rapid overgrowth of the *M* constituent once it appears.

8. The literature abounds with references to variation in the dermatophytes for which the dual phenomenon seems to be a logical interpretation.

9. The naming of species on the basis of gross cultural characteristics on standard media is untenable and results in confusion.

DIVISION OF PLANT PATHOLOGY,
UNIVERSITY OF CALIFORNIA,
BERKELEY, CALIFORNIA

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ADDITIONAL NOTES ON THE GENUS LEUCOPAXILLUS

ROLF SINGER AND ALEXANDER H. SMITH

(WITH 3 FIGURES)

Since the time our monograph on the genus appeared some additional data have accumulated which it appears desirable to publish. Resumption of exchange of material between this country and Sweden made it possible to check upon the Leucopaxilli of the Riksmuseet at Stockholm. Material of a new species, near *L. giganteus,* a new variety of *L. albissimus,* and excellent fresh material of *L. pulcherrimus* was also obtained. In addition Murrill described *Clitocybe Kappiana* from Florida, the type of which is very similar to *L. gracillimus* S. & S. (see Mycologia **36**: 553. 1944).

As for the material received from Stockholm, we did not find anything that would not confirm the arrangement as made in our monograph (Pap. Mich. Acad. Sci. **28**: 85–132. 1943). The majority of the specimens merely added some items to the list of material studied, and gave the forms of *L. amarus* some European representatives, which was to be expected since the extreme form, f. *alboalutaceus* (F. H. Møller, apud Lange) S. & S., was originally described from Denmark. The chief interest of the Swedish material centered around the specimens, type and co-type as well as other authentic material, of *L. rhodoleucus* (Rom.) Kühner, which had been interpreted in two different ways. We had previously decided to consider Maire's opinion in regard to this fungus as the one most likely to be correct, in contrast to Bresadola's note, both evidently made after a study of type material. All that needed to be done was to check the spores with Melzer's reagent; if the spores were amyloid, Maire's disposition of the fungus was correct, if not, the fungus would go in the genus *Rhodopaxillus* as suggested, or rather implied, by Bresadola. The type as well as all the other material proved to have strongly amyloid spores and this fully justified the arrangement made by Maire and later by us.

The following presentation is made in accordance with the order in which the species are treated in our monograph.

SECTION I: ASPROPAXILLI (Maire) S. & S.

Leucopaxillus septentrionalis sp. nov. FIGS. 1–3

Pileo (7)10–20(25) cm. lato, primum convexo, margine involuto, dein applanato vel disco subdepresso, demum late depresso numquam abrupte nec profunde depresso, sicco impolitoque, margine subtomentoso, disco glabro at saepe fissulo vel diffracto, numquam albo sed griseo vel avellaneo, aequaliter sordide alutaceo-grisello statu juvenili, interdum aquose-scrobiculato; carne crassa, albida; odore subspermatico, dein pungente; sapore ingrato; lamellis adnexis, dente decurrentibus, angustis (4–7 mm. latis), confertissimis, lamellulis postice rotundatis intermixtis, nullis vel paucis furcatis, separabilibus, saepe crispis et pallide cremeis in junioribus, demum alutaceo-tinctis; stipite brevi crassoque, 5–9 × 2.5–6 cm., solido, aequali vel subaequali, intus albido, dein sordido, extus carneo-alutaceo, impolito, interdum ad apicem subtomentoso, albo-mycelioso ad basin, demum sordide alutaceo saepeque obscurius tincto quam pileus, saepe glabrescente, colore tactu obscurato, humectando cinnamomeo-alutaceo; sporis 6.5–8.4 × 4–5 µ, levibus, amyloideis; cystidiis ad later aciemque lamellarum nullis; strato cuticulari ex hyphis subintertextis angustis consistente; hyphis omnibus fibuligeris. Caespitose vel gregario sub *Pinu ponderosa;* Bear Springs, Mt Hood National Forest, Ore. et Don Valley, Toronto, Ontario, Canada.

Pileus (7)10–20(25) cm. broad, at first obtuse or convex, with an inrolled margin, soon expanded to plane or the disc shallowly depressed, on further expansion becoming broadly depressed with a spreading to wavy and often lobed or sinuate margin, at times very irregular, never deeply or sharply depressed, margin remaining inrolled for a long time (long after it has become uplifted), surface—when not rain-soaked—dry and unpolished and with a feel like that of kid, margin unpolished to subtomentose, disc typically glabrous but often irregularly cracked and cuticle at times ruptured into scales of various types—concentric or diffracted, color never truly white or whitish, when wet dull grayish to near "avellaneous," buttons more or less sordid alutaceous-gray over all, watery spotlike depressions present on a few caps; flesh thick in disc (up to 2 cm.), tapered evenly to margin, whitish, unchanging, odor strong and subspermatic when specimens were first collected, later pungent, taste fairly strong and disagreeable; lamellae shallowly adnexed with a short decurrent tooth down apex of stipe, narrow (4–7 mm.), crowded, many lamellulae present and their

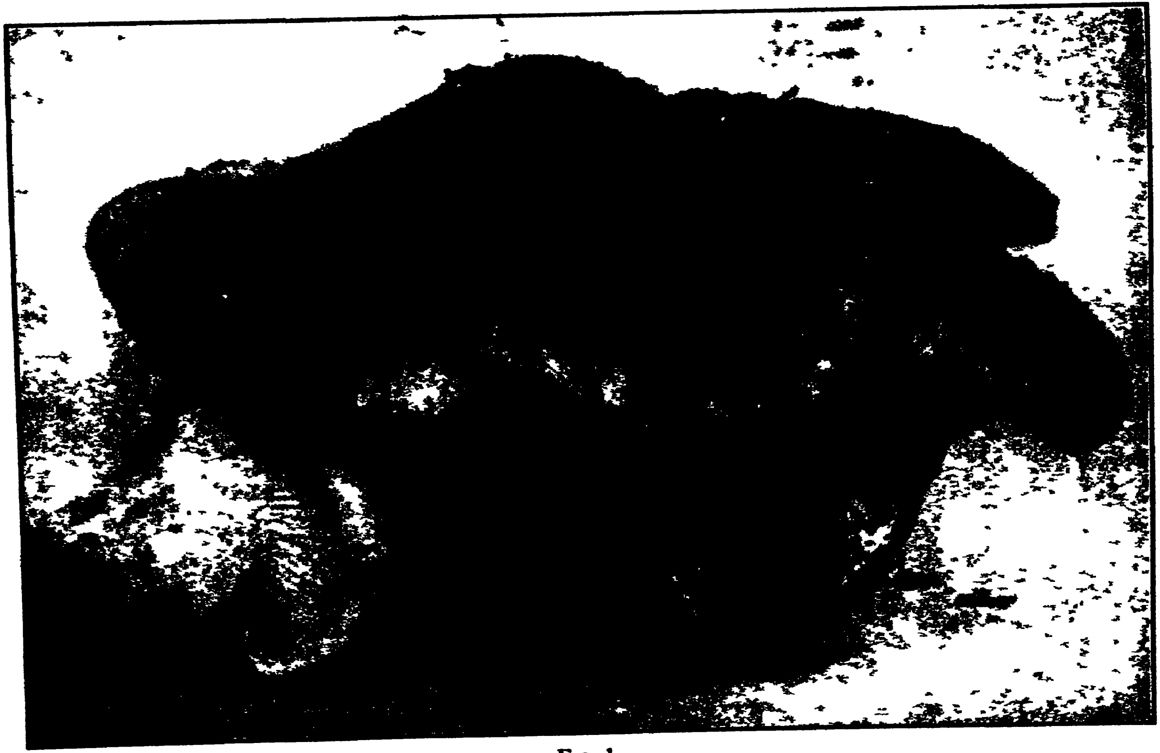

FIG 1.

inner extremities typically rounded, in some caps many gills forked near stipe but in others very few forked, readily separable, often crisped and pale cream color when young, in age flushed alutaceous, edges uneven, stipe short and thick, 5–9 cm. long, 2.5–6 cm. thick, solid, equal or slightly pinched off at base, whitish within when young but sordid in age, surface near "pinkish buff" and unpolished to subtomentose above, with whitish mycelium at base, no conspicuous rhizomorphs or moldy areas in surrounding debris, in age sordid alutaceous and often darker than the cap, often glabrescent, color change progressing from base upward and accentuated by handling or rubbing the surface or if stipe becomes wet, in undamaged specimens usually near "cinnamon buff."

Spores distinctly amyloid, smooth, 6.5–8.5(9) × 4–5 μ, subovoid to narrowly ellipsoid, with an oblique inconspicuous apiculus; basidia four-spored, narrowly clavate, 26–32(38) × 7–9 μ, hyaline but with oil globules as seen revived in KOH; pleurocystidia and cheilocystidia none seen; gill trama of interwoven thin-walled hyphae (6)8–17 μ in diam., clamp connections present; pileus trama with a thin cuticle of narrow (3–6 μ) somewhat interwoven, appressed hyphae, beneath it the hyphae intricately interwoven and 8–18 μ in diam., clamp connections present.

Habit, habitat and distribution. Cespitose-gregarious in large fairy rings under *Pinus ponderosa,* Bear Springs, Mt. Hood National Forest, Ore. The collection was found by Wm. B. Gruber, and consisted of several large rings each containing over a hundred carpophores. The type, Smith no. *24982,* was selected from one of the arcs. So far the species is known only from the type locality and one collection from Ontario (see observations).

Observations. The American collection reported by us under the name *L. lepistoides* is referable to *L. septentrionalis. L. lepistoides* is described as having greenish gray watery spots on the cap, stipe blue within at the base, and a white pileus at first, all characters definitely not possessed by *L. septentrionalis.* In addition, the latter is characterized by the manner in which the stipe darkens after handling or when water-soaked, and by a different habitat. The consistently narrow lamellae in even the largest pilei may also be distinctive. The two species, however, are similar in the manner in which the gills are attached to the stipe and in stature.

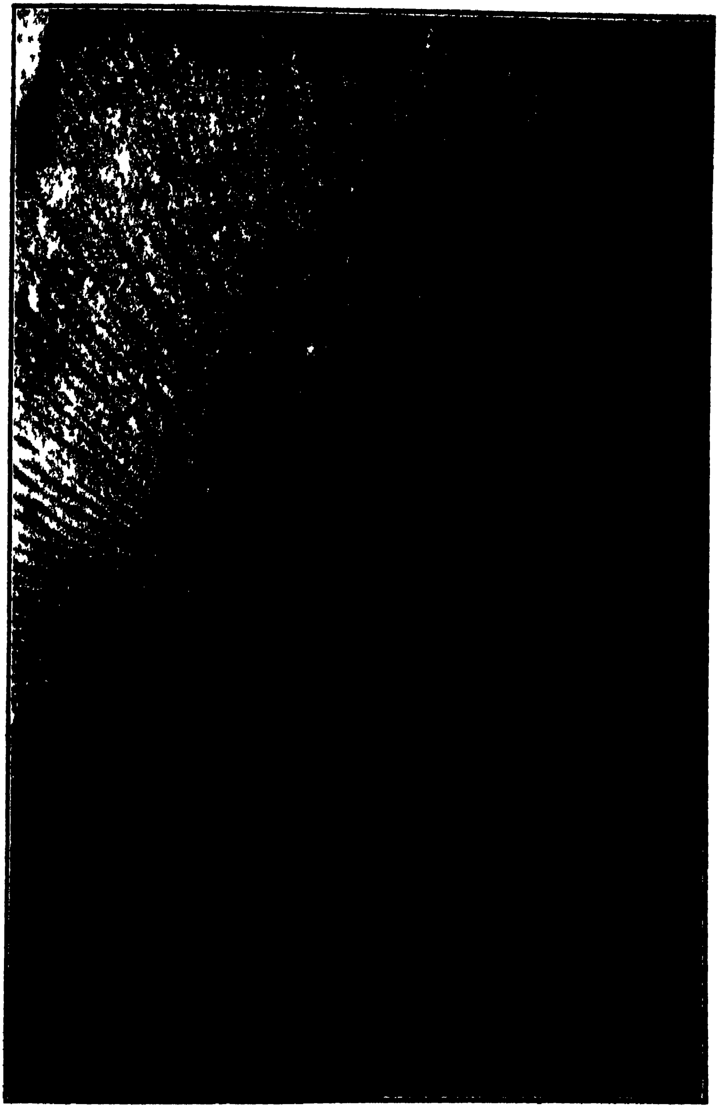

FIG. 2.

SECTION II: EU-LEUCOPAXILLUS

Leucopaxillus albissimus var. **monticola** var. nov.

Pileo 5–10 cm. lato, convexo, margine primum involuto pubescenteque, dein convexulo vel applanato, sicco, opaco, glabro, dein minute maculoso-squamuloso et conspicue areolato-rimoso Jove sicco, centro pallide cremeo-alutaceo, margine albido, carne admodum crasso firmoque, odore aromatico, sapore mitissimo; lamellis albis, desiccatione vix discoloratis, arcuatis, mox decurrentibus, angustis, confertissimis, furcatis; stipite 30–99 × 20–30 mm., clavato, saepe aggregato, solido, apice tomentoso-fibrilloso, albo vel pallide cremeo, exsiccando dealbato; mycelio basali albo, copioso; sporis 6.5–8 × 4.5–5 μ amyloideis, sparse verruculosis; pleurocystidiis (prope aciem paucis) cheilocystidiisque flexuosis, hyalinis, 34–46 × 3–5 μ; subhymenio tenui, ramoso; hyphis cuticularibus intertextis et multis hyphis erectis e strato illo projicientibus, 20–50 × 4–5 μ, fibuligeris. Caespitose sub arboribus frondosis et coniferis. Payette Lake, Idaho; Sequoia National Park, California, et Pinkham Notch, Massachusetts, U. S. A.

Pileus 5–10 cm. broad, convex with an inrolled pubescent margin at first, becoming broadly convex to plane, surface dry and unpolished, glabrous at first but soon developing minute spot-like scales and in addition becoming conspicuously areolate-cracked in dry weather, central portion pale creamy tan (near "cinnamon buff" but paler), whitish toward the margin; flesh very thick and firm; white, unchanging, not readily attacked by insect larvae, odor when fresh strong and aromatic, pleasant, when dried odor distinctive and somewhat disagreeable, taste perfectly mild; lamellae white, hardly discoloring in drying, arcuate to truly decurrent, narrow, crowded, many forked, thin and readily breaking transversely, edges even to slightly floccose; stipe 3–9 cm. long, 2–3 cm. thick at apex, clavate, solid, hard, surface unpolished and tomentose-fibrillose to apex, sometimes minutely scurfy, white or tinged pale cream color, drying whitish, several often fused together at the base, with a copious white basal mycelium penetrating through the duff for some distance.

Spores 6.5–8 × 4.5–5.5 μ, broadly ellipsoid, strongly amyloid, with small scattered warts (at times appearing almost smooth); basidia four-spored, 36–42 × 8–9.5 μ, clavate; pleurocystidia rare and found mostly near the gill edge, 34–46 × 3–5 μ, flexuous, hyaline; cheilocystidia very abundant to scattered, similar to pleurocystidia, gill trama subregular, very compact, hyaline, the hyphae 3–6 μ in diam., subhymenium thin and much branched; pileus trama with a cuticle of interwoven hyphae from which numerous hyphae 20–50 μ long and 4–6 μ in diam. project, their apices usually rounded, clamp connections at cross walls (the upright hyphae almost forming a turf), trama beneath the cuticle of very compactly interwoven hyphae

Habit, habitat and distribution Cespitose under conifers and hardwoods The type, Wm B Gruber *P-27*, was collected at Payette Lakes, Idaho, August, 1943, under *Pinus ponderosa*

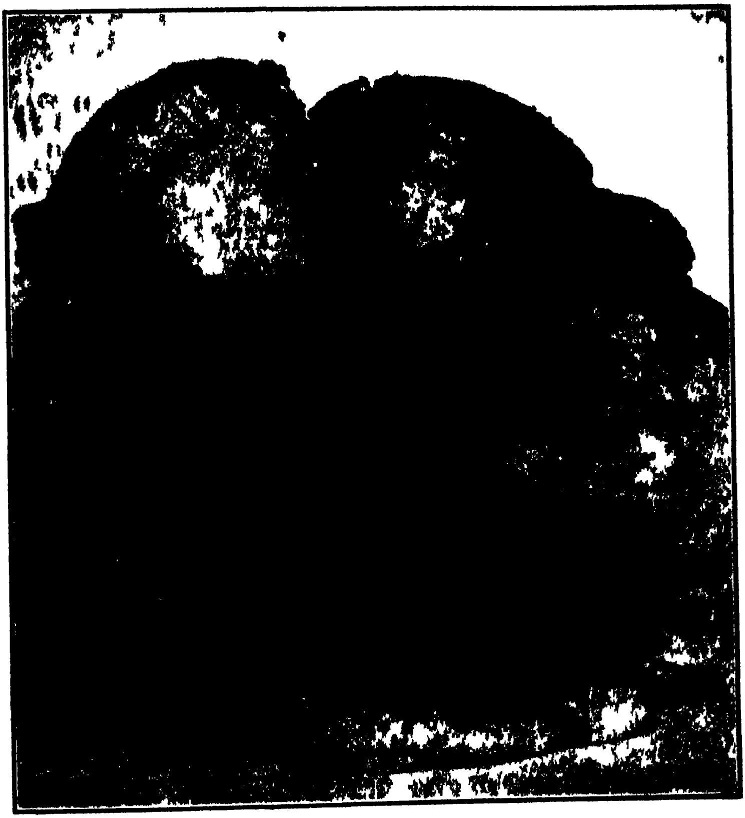

FIG 3

The description has been drawn entirely from the type collection Material identified as this variety was collected by Sam Pusateri, of the National Park Service, at Sequoia National Park, Calif, Nov 1945 (Pusateri no *68*) The senior author found it under beech at Pinkham Notch, White Mts, New Hampshire (Singer *WM43*), August 7, 1945

Observations. This variety could be referred to var. *piceinus* were it not for the mild taste, and it might possibly be referred to var. *paradoxus* if one were to disregard the abundant cheilocystidia. It serves well to bring into focus the evolutionary tendencies within the species, which we emphasized in our monograph. Var. *monticola,* as represented by the type, showed a pronounced tendency for the gills to fork, but not much emphasis should be given to this character until a large series of collections have established it as constant.

Pusateri's collection, from under *Libocedrus decurrens,* is placed here provisionally since neither of us has seen fresh material. Mr. Pusateri's comments are as follows: "Ground covered with snow (12 inches deep) except under trees—one cluster weighed 10 lbs. —several such clusters within a few feet. Temperature below 32 in this locality for past six weeks." The elevation was approximately 4500 ft. The specimens dried well and show no indication of frost damage. If his material, as seems to be the case as far as the microscopic characters go, actually belongs in this variety, the dimensions of the fruiting bodies as well as of the clusters will have to be revised upward.

LEUCOPAXILLUS ALBISSIMUS var. TYPICUS

Material studied: An excellent collection was found in a mixed forest near Rhododendron, Ore., Oct. 24, 1944, by Wm. B. Gruber and the junior author (Smith, *20172*). The filamentose, flexuous cheilocystidia are fairly abundant on these fruiting bodies.

LEUCOPAXILLUS ALBISSIMUS var. PARADOXUS (Cost. & Duf.) S. & S.

Material studied: We can now add two specimens from Sweden, south of Kristianstad (no. *10194*), coll. P. Tufveson, which is preserved in the Romell Herbarium (Riksmuseet) with the indication "*Lepista amara* Pat. t. 618,"[1] and another specimen collected in Stockholm, Ladugärdsgarde, by Margareta Akerhielm, both good specimens and photographs, conform with our description (*l.c.* p. 112). We can also add another specimen from France, Noisy-le-Sec, coll. L. Joachim and incorporated in the Romell Herbarium.

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[1] It is true that Patouillard's interpretation of *Agaricus amarus* A. & S. ex Fr. appears to be the same as *L. albissimus* var. *paradoxus* rather than *L. amarus.* However, his name is merely erroneous and cannot be accepted.

LEUCOPAXILLUS PULCHERRIMUS (Pk.) S. & S.

Pileus 5–10 cm. broad, plane or nearly so and with an incurved margin at first, becoming shallowly depressed to somewhat funnel-shaped or disc merely flat and margin uplifted, surface moist and hygrophanous at maturity, when young moist but also unpolished, "amber yellow" fading to "massicot yellow," margin not striate when moist but frequently incised or wavy at maturity; flesh soft and fragile, watery yellowish, fading to whitish, no odor or taste, no color change when bruised; lamellae "cartridge buff" with a "pinkish buff" reflection, decurrent, close, narrow (3–5 mm.), very few anastomosing on stipe, edges even; stipe short, 2–5 cm. long, 1–2 cm. thick, enlarged upward, solid, pallid, yellow within, surface yellowish and unpolished, with white mycelium around the base binding much debris together; spores white in deposits.

The microscopic characters are as we described them previously for the type. Josserand (Bull. Soc. Myc. Fr. **56**: 31, fig. 117) has found this species in France and has given an excellent drawing of the spore. The description of the fruiting bodies given above was drawn from specimens collected under beech near the edge of a swamp, Milford, Mich., Oct. 4, 1945, Smith no. *21031*. The species appears to be very rare.

LEUCOPAXILLUS LATERARIUS (Pk.) S. & S.

Material studied: Dried material from Peabody, Mass., Oct. 1911, coll. R. B. Mackintosh. This was determined as *Clitocybe gigantea* by W. G. Farlow, and appears to be the first indication of this species in Massachusetts. During the summer of 1946 *L. laterarius* was very abundant in the vicinity of the University of Michigan's Biological Station at Douglas Lake, Michigan and it was also found at Cross Village, Smith nos. *21574* and *21695*. Fresh material from Mountain Lake, Va., was collected by the senior author July 22, 1946, under oak on leaf-mold. In this collection the pileus was whitish and the lamellae pale pink; the taste was very bitter, and the odor aromatic—resembling fresh sauerkraut. The spore print is pure white. This is apparently the first record of this species from Virginia.

LEUCOPAXILLUS RHODOLEUCUS (Romell) Kühner

The description of the Swedish plant and the description given by Maire, as copied in our monograph (*l.c.* p. 119), refer to the same fungus and have to be combined. Our personal examination of the microscopical characters follows:

Spores 7.5–8.3 × 5–6 µ, hyaline, warty, amyloid, thin-walled, without a smooth disc above the hilar end, short-ellipsoid; basidia 20–43 × 8.2 µ, four-spored; cystidia and cheilocystidia none; subhymenium about 15 µ thick, appearing thicker because of the septate base of many basidia (the short ones), ramose; trama regular, consisting of interwoven, densely packed, elongate hyaline hyphae; all hyphae with clamp connections.

Note: The figures show cream colored lamellae; the red tints shown in some (FIGS. *B* and *C* of the original paintings by Romell) are a pale "orange vinaceous" of Ridgway.

LEUCOPAXILLUS TRICOLOR (Pk.) Kühner

Material studied: Abundant material of this fungus was found in the vicinity of the University of Michigan's Biological Station during the summer of 1946 (Smith nos. *21806, 22137;* also at Harbor Springs, Smith no *22080*). It was first found on July 22 on Grape Vine Point and was not infrequent in the hardwood areas throughout August. To our knowledge this is the first time the species has been encountered as a common element in the agaric flora of a local area. In coll. *21806* the carpophores were subcespitose.

LEUCOPAXILLUS AMARUS (A. & S. ex Fr.) Kühner, f. typicus

Material studied: Both sf. *major* and sf. *minor* are represented in Swedish material from Experimentalfältet, Stockholm; from Stockholm toward "Skuggan"; Upsala, Upland; Stockholmstrakten; Stockholms-Näs and Saltsjö-Järla, Södermanland collected by Romell himself, others by Kugelberg, Bengt Cortin and H. v. Post.

F. VULPECULUS (Kalchbr.) S. & S.

There is a specimen from spruce woods, collected by Post in Stockholm, Ugglevisskogen, Nov. 10, 1894, with a picture, and also notes in Swedish (no. *9279*). Romell notes that this is "*C. amara* but taste not *bitter*." The cheilocystidia are drawn as they are in f. *typicus,* not as indicated by Kühner, but the senior author was unable to check on this point since the cheilocystidia are not well preserved in this specimen.

F. BICOLOR (Murr.) S. & S.

Material from Stockholm, Djurgarden, Djurgardsbrunn, H. Kugelberg, Nov. 10, 1889, determined (probably by Romell) as *Clitocybe amara,* is obviously this form, which is new for Europe. There is no incrusting pigment on the hyphae of the cuticle, and the colors are exactly those observed in American material.

LEUCOPAXILLUS GRACILLIMUS S. & S.

The lamellae of *Clitocybe Rappiana* Murr. (Proc. Fla. Acad. Sci. 7: 108. 1944, published 1945) are exactly as crowded as those of *L. gracillimus.* There is no doubt but that this Floridan species is closely related to the fungus from Brazil. It has been pointed out before that the fungus described by Murrill is larger than *L. gracillimus.* As to color, if the term latericious as used by Murrill is approximately equal to the term sanguineus of Rick, the Florida agaric may be considered to be a larger geographical race of *L. gracillimus.* However, the color of the dried specimens is not redder than that of *L. amarus* in dried caps. If the color of *C. Rappiana* should turn out to be the same as that of *L. amarus* and *L. gracillimus* should have a redder color when fresh, then we believe that it might be best to consider *C. Rappiana* as an autonomous form intermediate between *L. amarus* and *L. gracillimus.* Since *L. amarus* f. *gracilis* is also somewhat intermediate—though in another sense—between these two species, we have also compared f. *gracilis* with *C. Rappiana.* However, we were not satisfied as to their identity.

Under these circumstances it appears that *C. Rappiana,* though not identical with the type form of *L. gracillimus,* is too similar to it in fundamental characters to warrant its being maintained as an autonomous species. We know its approximate position in the classification of *Leucopaxillus,* but hesitate to transfer the name to this genus until studies of fresh material have clarified its status further.

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The authors wish to express their appreciation and gratefulness to Dr. Th. Arwidsson, Riksmuseet, Stockholm, for the valuable type material put at their disposal during the preparation of the present paper.

FARLOW HERBARIUM,
HARVARD UNIVERSITY,
CAMBRIDGE, MASS.
UNIVERSITY OF MICHIGAN HERBARIUM,
UNIVERSITY OF MICHIGAN,
ANN ARBOR, MICHIGAN

SELENOPHOMA ON GRASSES, III[1]

RODERICK SPRAGUE[2] AND A. G. JOHNSON[3]

Frandsen (5) in 1943 erected the genus *Lunospora* apparently with the same concept as the genus *Selenophoma* Maire (11), an earlier name taken up by Sprague and A. G. Johnson (21, 22). Frandsen proposed ten species of *Lunospora*. The type species, *L. oxyspora* (Penz. and Sacc.) Frandsen, based on *Septoria oxyspora* Penz. and Sacc., we consider a synonym of *S. donacis* (Pass.) Sprague and A. G. Johnson (21).

Frandsen proposed *Lunospora curva* (Karst.) Frandsen based on *Septoria curva* Karst. (8). Petrak, in 1940 (15, p. 239), assigned this fungus to *Selenophoma curva* (Karst.) Petrak. The writers agree with Petrak that this species belongs in the genus *Selenophoma* but prefer to place it in *S. donacis*. This species has boomerang-shape or falcate spores, 18–30 × 2–4 μ (13, 20). Karsten (8) described *Septoria curva* as having spores 14–20 × 3.5–4.5 μ. Saccardo (16) recorded the same measurements whereas Grove (7) gives slightly longer and narrower dimensions, 14–25 × 3–4 μ. Petrak (15, p. 239) gives the spore measurements as 10–16 × 2.5–3.5 μ. Material of Petrak's Flora Bohemiae et Moraviae exs., II ser., no. *540* on *Phragmites communis* has spores 14–19 × 2.5–3.1 μ, with some uniseptate spores. The uniseptate spores are somewhat lunate rather than boomerang-shape as in most material of *S. donacis* on *Arundo* and *Phalaris*. Except for the septa, the spores of this collection resemble rather closely those of *S. donacis* var. *stomaticola* (Bäuml.) Sprague and A. G. Johnson (22). The specimens were collected May 8, 1912, and, therefore, the spores clearly had overwintered on the old culms. The senior author has examined similar material on Petrak's Fungi Polonici exs. no. *512* collected May 12, 1917 on old culms. In August, 1944, he also collected scanty leaf spot material on *Phragmites communis* Trin. on the south shore of Devil's Lake near Ft. Totten, N. Dak., in which spores were non-septate, 13–20 × 2.5–3.2 μ, borne in lesions having the characteristic, narrow, pale-tinted border produced by *S. donacis* on most hosts.

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[1] Coöperative investigations between the Divisions of Cereal Crops and Diseases, Forage Crops and Diseases, and Soils, Fertilizers and Irrigation, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration; and the Nursery Division, Soil Conservation Service, U. S. Department of Agriculture, and the North Dakota and Washington Agricultural Experiment Stations. Published as scientific Paper No. 720, Washington College of Agriculture and Agricultural Experiment Station.

[2] Formerly Pathologist, Division of Cereal Crops and Diseases and Collaborator, Division of Forage Crops and Diseases; now with the Department of Plant Pathology, Washington State College, Pullman, Wash.

[3] Principal Pathologist, Division of Cereal Crops and Diseases.

Grove (7) classifies *Septoria curva* as *Rhabdospora curva* (Karst.) Allesch., Allescher (1) having placed it in the latter genus in 1901. Grove mentions that he considered the fungus close to *Septoria oxyspora*, which we regard as a synonym of *Selenophoma donacis*. Furthermore, Sydow's Mycotheca Germanica No. *1667*, collected on dry culms of *Phragmites communis*, May 13, 1917, is labelled *R. curva*, which we prefer to consider a synonym of *S. donacis*.

Selenophoma is fundamentally a genus with non-septate spores. Septa, when they occur, appear in spores that have been mature for a long time, often after they have passed through a winter on dead host parts. *Phragmites communis* is a particularly lush host for saprophytic fungi as indicated by the confusing array of saprophytic, pycnidial forms that have been described on it. With everything considered, therefore, the presence of a few uniseptate spores, especially in overwintered material on *P. communis*, is not sufficient reason to exclude *Septoria curva* from the previously described *Selenophoma donacis*. Incidentally, Petrak (15, p. 238), in his recent discussion of *Septoria curva*, states that the spores in the material with which he worked were non-septate. The senior author has seen septate spores in overwintered material of *S. donacis* var. *stomaticola* on *Elymus glaucus* Buckl. collected by him west of Skamania, Wash. (O.S.C. *768*). The spores in this material were 13–20 × 2.0–3.3 μ, borne in brown pycnidia 110–160 μ in diameter with typically small subcarbonaceous cellular structure. At one time the senior author assigned this to *Septoria curva*, but he now feels that the differences in the pycnidia and spores are due to overwintering rather than to any fundamental differences in morphology. The type of *Phyllosticta stomaticola* Bäuml., which is the basis for *S. donacis* var. *stomaticola,* is itself based on winter pycnidia. In the original description, however, the spores were not described as being septate. In general, in practically all material on all hosts except *P. communis,* the spores are non-septate. Diedicke described (4, p. 531) and illustrated (4, p. 432, FIG. 27) the spores of *Septoria curva* as non-septate, but as noted by Grove (7), he (4, p. 532) commented that they seem finally to become unequally triseptate. Likewise Migula (12, p. 447, pl. 57, FIG. 18) described and illustrated the spores of this fungus as non-septate.

Demidova (3, p. 152) described and illustrated 7-septate, falcate spores for *Septoria falcispora* Demidova on *Briza media, Festuca pratensis, Poa pratensis,* and *Secale cereale. Septoria falcispora* differs widely from *Selenophoma,* however, and possibly may belong in the genus *Phaeoseptoria* (18). The small, hyaline, non-septate, falcate spores described and illustrated by Demidova (3, p. 152, FIG. 24) as *Septoria secalina* Sacc. on *Secale cereale* are microspores of *Septoria secalis* Prill. and Del. (19, p. 84). Those referred to by her (3, p. 152, FIG. 23) as *S. cristati* Hollòs on *Triticum vulgare* are microspores of *S. tritici* Rob. (19, p. 16, FIG. 1, A, K, N). Those referred to by her (3, p. 152, FIG. 25) as *S. secalina* Sacc on *Agrostis alba* are microspores probably of *S. calamagrostidis* (Lib.) Sacc. or *S. triseti* Speg. (19, p. 95). Therefore, none of these belongs in the genus *Selenophoma.*

The following additional species referred to by Frandsen (5) are: *Lunospora culmifida* (Lind) Frandsen, *L. suboxyspora* (Lobik) Frandsen, *L. culmorum* (Grove) Frandsen, and *L. lunata* (Grove) Frandsen all belong in *Selenophoma donacis* var. *stomaticola.* Likewise Frandsen's *L. baldingerae,* which he described as new, is indistinguishable from *S. donacis* on *Arundo donax* L. and is assigned to that species (20). *S. donacis* is common on *Phalaris* (*Baldingera*)*arundinacea* L. in the western United States.

Frandsen (5, p. 74) also described *Lunospora avenae* as new on *Avena elatior,* with spores 15–17 × 2.5–3.5 μ. *A. elatior* is the type host for *Phyllosticta stomaticola* Bäuml. on which *Selenophoma donacis* var. *stomaticola* is based. Although the spores are slightly wider than those described for *S. donacis* var. *stomati-*

cola, the writers feel that *L. avenae* Frandsen likewise can be assigned to *S. donacis* var. *stomaticola.* Likewise, also, *Lunospora penniseti* (Trott.) Frandsen (5, p. 72) apparently should be referred to *Sel. donacis* var. *stomaticola.*

Lunospora bromigena (Sacc.) Frandsen (5, p. 72) clearly should be referred to *Selenophoma bromigena* (Sacc.) Sprague and A. G. Johnson (21).

According to the above, therefore, the pertinent synonymy would be as follows:

SELENOPHOMA DONACIS (Pass.) Sprague and A. G. Johnson, 1940 (21)

Syn.—*Septoria donacis* Pass., 1878 (13, 23)
Septoria oxyspora Penz. and Sacc., 1884 (14)
Septoria curva Karst., 1887 (8)
Rhabdospora curva Allesch., 1901 (1)
Selenophoma curva Petrak, 1940 (15)
Lunospora curva Frandsen, 1943 (5)
L. oxyspora Frandsen, 1943 (5)
L. baldingerae Frandsen, 1943 (5)

SELENOPHOMA DONACIS var. STOMATICOLA (Bauml.) Sprague and A. G. Johnson, 1945 (22)

Syn.—*Phyllosticta stomaticola* Bäuml., 1890 (2)
Septoria culmifida Lind, 1907 (9)
S. oxyspora var. *culmorum* Grove, 1916 (6)
S. oxyspora var. *penniseti* Trott., 1916 (24)
S. suboxyspora Lobik, 1928 (10)
S. lunata Grove, 1935 (7)
Lunospora culmifida Frandsen, 1943 (5)
L. culmorum Frandsen, 1943 (5)
L. suboxyspora Frandsen, 1943 (5)
L. lunata Frandsen, 1943 (5)
L. penniseti Frandsen, 1943 (5)
L. avenae Frandsen, 1943 (5)

SELENOPHOMA BROMIGENA (Sacc.) Sprague and A. G. Johnson, 1940 (21)

Syn.—*Septoria bromigena* Sacc., 1915 (17)
Lunospora bromigena Frandsen, 1943 (5)

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NOTES AND BRIEF ARTICLES

SEAVERINIA GERANII

This discomycete has been reported heretofore from only four stations, Van Cortlandt Park (the type locality) and Bronx Park, both in New York City, one in Wisconsin and one in the Cayuga Lake Basin in the McLean Bogs near McLean, New York. Two new stations were found in the Basin during the spring of 1947, one at Michigan Hollow near Danby, and the other in Coy Glen near Ithaca. In each case ascospore shootings recovered the characteristic imperfect stage recently described and figured by Seaver (Mycologia 39: 113–119. 1947) and confirmed the determination as *Seaverinia Geranii* (Seaver and Horne) Whetzel. The collections have been filed in the Cornell Plant Pathology Herbarium under the accession numbers 36929 and 36931.—RICHARD P. KORF.

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[1] Compiled by the Secretary-Treasurer, Ann Arbor, Michigan, September 3, 1947.

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BECHTEL, DR. ALBERT R., *Wabash College, Crawfordsville, Ind.* (Mycology.)

BENEDEK, DR. TIBOR, *1706 E. 56th St., Chicago 37, Ill.* (Medical mycology.)

BENEKE, EVERETT S., *308 Natural History Bldg., University of Illinois, Urbana, Ill.*

BENHAM, DR. RHODA WILLIAMS, *College of Physicians & Surgeons, Columbia University, 630 W. 168th St., New York City.* (Human pathogens.)

BENJAMIN, RICHARD K., *Department of Botany, Room 308, Natural History Bldg., University of Illinois, Urbana, Ill.*

BENNETT, RALPH E., Research Biologist, Commercial Solvents Corporation, *724 South 25th St., Terre Haute, Ind.* (Physiology of fungi.)

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BERRY, DR. EDWARD C., *1008 Marshall St., Richland, Wash.*

BERT, RUDOLPH A., *U. C. Deciduous Fruit Station, Route A, Box 92, San Jose, Calif.*

BESSEY, DR. ERNST A(THEARN), Professor of Botany, retired, *Michigan State College, East Lansing, Mich.* (Phylogeny; Phycomycetes.)

BHARGAVA, K. S., *Rothamsted Experiment Station, Harpenden, Herts, England.*

BINGHAM, R. T., *618 Realty Building, Spokane 8, Wash.*

BISHOP, DR. HARLOW, *Cottage Avenue, Nanuet, N. Y.* (Sexuality in aquatic Phycomycetes.)

BITANCOURT, AGESILAU A., *Instituto Biologico, Caixa postal 119A, São Paulo, Brazil.*

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BOTTS, WILLIAM, *315 Summit Lane, Fort Mitchell, Ky.* (Mycetozoa.)

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BOYCE, PROF. J. S., Professor of Forest Pathology, *Yale University, New Haven 11, Conn.* (Fungi on trees and wood; forest pathology.)

BRASFIELD, T. W., *521 Lexington St., Homden 14, Conn.*

BRAUN, ALVIN J., Assistant Professor, *New York State Agricultural Experiment Station, Geneva, N. Y.* (Small fruit diseases; root rots.)

BRIAN, DR. PERCY W., *Imperial Chemical Industries Ltd., Butterwick Research Laboratories, Welwyn, Herts, England.* (Physiology of fungi; antibiotics.)

BROOKS, TRAVIS E., Botany Department, *Kansas State College, Manhattan, Kans.*

BROWN, A. M., Assistant Plant Pathologist, *Dominion Laboratory of Plant Pathology, University of Manitoba, Winnipeg, Man., Canada.* (The plant rusts; sexuality and genetics.)

BROWN, JAMES GREENLIEF, Head, Department of Plant Pathology, College of Agriculture; Plant Pathologist, Arizona Agricultural Experiment Station, University of Arizona, *Box 4672, University Station, Tucson, Ariz.* (Diseases of cotton and vegetables.)

BRUNEL, JULES, Directeur, *Institut de Botanique, Université de Montréal, 4101 est, rue Sherbrooke, Montréal, Quebec, Canada.* (General taxonomy.)

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Caldwell, Gwendolyn Burton, *662 Milledge Avenue, Athens, Ga.*

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Carvajal, Dr. Fernando, *303 Diehl Drive, Lawrenceburg, Ind.*

Cash, Miss Edith K(atherine), Associate Mycologist, *U. S. Plant Industry Station, Beltsville, Md.* (Taxonomy of Discomycetes.)

Charles, Miss Vera K., *2039 New Hampshire Avenue, Washington, D. C.*

Chen, Dr. S(han-) M(ing), *c/o K. W. Wagner, 105 Winona St., Northfield, Minn.*

Chilton, Dr. St. John P., *Department of Botany, Bacteriology and Plant Pathology, Louisiana State University, Baton Rouge, La.*

Chiu, Wei-Fan, *Department of Plant Pathology, University of Wisconsin, Madison, Wisc.*

Christenberry, Dr. George A., Associate Professor of Biology, *Furman University, Greenville, S. C.* (Mucorales; Phycomycetes.)

Christensen, Clyde M., *University Farm, St. Paul, Minn.* (Forest pathology and mycology.)

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Christison, Miss Isabel B., *American Type Culture Collection, 2029 M Street, N.W., Washington, D. C.* (Morphology and taxonomy.)

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Clark, Dr. Marie B., *Department of Botany, Howard University, Washington, D. C.* (Taxonomy of agarics.)

Coe, Donald M., *Botany Hall, Iowa State College, Ames, Iowa.*

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Conners, Ibra Lockwood, Associate Plant Pathologist, *Central Experimental Farm, Ottawa, Ontario, Canada.* (Rusts and smuts; plant disease survey.)

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CRANDALL, BOWEN S., Chief, Department of Plant Pathology and Entomology, *Estación Central de Colonizacion en Tingo Maria, Huanuco, Peru, S. A.* (Root diseases, especially Phytophthora vascular diseases.)

CREAGER, DR. DON BAKER, *337 Natural Resources Building, Urbana, Ill.*

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DAMON, SAMUEL CHESTER, II, Graduate Assistant, *Department of Botany, Brown University, Providence, R. I.*

DARBY, RICHARD T., *5029 Hazel Ave., Philadelphia 43, Pa.* (Physiology of fungi.)

DARKER, GRANT D., Mycologist, *Ben Venue Laboratories, Inc., Bedford, Ohio.* (Antibiotics; Hypodermataceae.)

DARLEY, ELLIS F(LECK), *3655 Ames St., Denver 14, Colo.*

DAVIDSON, ROSS W., Pathologist, *Plant Industry Station, Beltsville, Md.* (Fungi causing tree diseases.)

DAVIS, DR. B(ENJAMIN) H(AROLD), *N. J. Agricultural Experiment Station, New Brunswick, N. J.* (Taxonomy; parasitic fungi.)

DEARNESS, DR. JOHN, *30 Marley Place, London, Ontario, Canada.* (Mycology; botany; entomology.)

DE LAMATER, EDWARD D., M.D., Mycologist, in charge Mycology Laboratory, *Mayo Clinic, Rochester, Minn.* (Medical mycology.)

DENNISON, MRS. RAYMOND A., *1029 Margaret St., Gainesville, Fla.* (Myxomycetes.)

Dick, Esther A(melia), Assistant in Botany, *Brown University, Providence 12, R. I.* (Boletaceae.)

Diehl, William W(ebster), Mycologist, *U. S. Department of Agriculture, Plant Industry Station, Beltsville, Md.* (Ascomycetes; Fungi Imperfecti; Balansia and Dothichloe; history of mycology.)

Dodge, Bernard O., Plant Pathologist, Emeritus, *New York Botanical Garden, New York 58, N. Y.* (Mycogenetics; plant diseases.)

Dodge, Dr. Carroll W(illiam), *Missouri Botanical Garden, 2315 Tower Grove Ave., St. Louis, Mo.* (Morphology and taxonomy of lichens and human pathogens, Hymenogasteraceae.)

Dosdall, Dr. Louise, *University Farm, St. Paul, Minn.* (Diseases of ornamental plants.)

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Downing, Mary H., Mycologist, *Biological Laboratories, Quartermaster Depot, 2800 S. 20th St., Philadelphia 45, Pa.* (Biological deterioration of materials used in industrial manufacture.)

Drake, Charles H., Assistant Professor of Bacteriology, *Department of Bacteriology, Washington State College, Pullman, Wash.* (Medical mycology.)

Drayton, F. L., Principal Plant Pathologist, *Division of Botany and Plant Pathology, Central Experimental Farm, Ottawa, Ontario, Canada.* (Mycology and administration.)

Drechsler, Dr. Charles, *Bureau of Plant Industry, U. S. Department of Agriculture, Beltsville, Md.* (Fungi associated with root rot, including predaceous forms.)

Du Charme, E. P., *Citrus Experiment Station, Lake Alfred, Fla.*

Duddington, C. L., *The Polytechnic, Department of Biology, 309 Regent St., London W. 1, England.*

Dulaney, Eugene L., Microbiologist, *Merck & Company, Inc., Rahway, N. J.* (Basidiomycetes; physiology of fungi.)

Dulsey, Miss C. G., *Indiana State Teachers College, Terre Haute, Ind.*

Eckert, Theodore E., *Whitney Point, N. Y.*

Eddins, Dr. A. H., *Agricultural Experiment Station, Hastings Laboratory, Hastings, Fla.* (Parasitic fungi.)

Edgerton, Claude W., Head, *Department of Botany, Bacteriology and Plant Pathology, Louisiana State University, Baton Rouge, La.* (Diseases of southern crops; genetics and cytology of Glomerella.)

Ehrlich, John, Head, Division of Mycology and Antibiotics, *The Research Laboratories, Parke Davis & Co., Detroit 32, Mich.* (Antibiosis; forest fungi.)

Ellis, Dr. D(on) E(dwin), Associate Research Professor of Plant Pathology, *Plant Pathology Section, N. C. State College, Raleigh, N. C.* Box 5397. (Vegetable crop diseases; forest tree diseases.)

Ellison, Bernard, *New York State Teachers College, Albany, N. Y.*

Emerson, Ralph, Assistant Professor of Botany, *Department of Botany, University of California, Berkeley, Calif.* (Experimental studies of algae and fungi.)

EMMONS, DR. CHESTER W., Principal Mycologist, *National Institute of Health, Bethesda 14, Md.* (Medical mycology; cytology of fungi.)

ESPENSHADE, MARLIN A., *George Washington University, School of Medicine, 1335 H St., N.W., Washington, D. C.* (Botany and mycology; penicillin.)

EZEKIEL, DR. WALTER N(APHTALI), Head Mycologist, *Bureau of Ordnance (RELE), Navy Department, Washington 25, D. C.* (Fungus and moisture-proofing of electrical equipment; Phymatotrichum root rot; physiology of parasitism; Sclerotinia.)

FAULL, JOSEPH HORACE, Professor of Forest Pathology, Emeritus, *Arnold Arboretum, Harvard University, Jamaica Plain, Mass.* (Melampsoraceae.)

FAWCETT, DR. H(OWARD) S(AMUEL), *Citrus Experiment Station, University of California, Riverside, Calif.* (Study of fungi, especially citrus fungi in relation to diseases, and virus diseases of citrus.)

FAY, DOLORES J., *115 S. 11th St., Newark 7, N. J.*

FENNELL, DOROTHY J., *Northern Regional Research Laboratory, 825 N. University, Peoria, Ill.*

FISCHER, GEORGE W., Head, *Department of Plant Pathology, Washington State College, Pullman, Wash.* (Smuts of grasses.)

FISHER, FRANCINE E., Associate Plant Pathologist, *University of Florida, Citrus Experiment Station, Lake Alfred, Fla.* (Entomogenous fungi and biological control.)

FITZPATRICK, DR. HARRY M(ORTON), Professor of Mycology, *Department of Plant Pathology, Plant Science Building, Cornell University, Ithaca, N. Y.* (General mycology; Pyrenomycetes.)

FORD, AUSTIN J., *310 Lane St., Jessup, Pa.*

FOWLER, MARVIN E(DWARD), *Division of Forest Pathology, U. S. Department of Agriculture, Bureau of Plant Industry, Washington, D. C.* (Diseases of forest trees and forest products.)

FRIEDMAN, DR. BERNARD A., Associate Pathologist, *U. S. Department of Agriculture, Room 1022, 641 Washington St., New York 14, N. Y.* (Market diseases of fruits and vegetables; phytopathogenic bacteria.)

FRITZ, CLARA W., Timber Pathologist, *Forest Products Laboratories, Metcalfe and Isabella Sts., Ottawa, Ontario, Canada.* (Decay and stain in wood.)

FULMER, W. L., *505 Boylston North, Seattle, Wash.*

GAINES, J. G., *Coastal Plain Experiment Station, Tifton, Ga.*

GAMMEL, DR. JOHN A(NTHONY), *Department of Dermatology, 2085 Adelbert Rd., Cleveland, Ohio.* (Medical mycology.)

GARCES, CARLOS O., *Palace 58–59, Medellin, Colombia, S. A.* (Cacao diseases.)

GARDNER, MAX W., Professor of Plant Pathology, *107 Hilgard Hall, University of California, Berkeley 4, Calif.* (Plant pathology.)

GARDNER, MISS PHYLLIS, *Department of Botany, University of California, Berkeley 4, Calif.*

GAUVEY, MARY P., *705 Grand Avenue, Dayton, Ohio.*

GEORG, LUCILLE K., *50 Haven Ave., New York 32, N. Y.* (Medical mycology.)

GILBERT, E. J., *4 rue de Musset, Paris 16, France.*

GILBERT, E. M., Emeritus Professor of Botany, *307 Biology Building, University of Wisconsin, Madison 6, Wis.*

GILBERT, DR. FRANK A., *2262 Yorkshire Road, Columbus 8, Ohio.*

Gilkey, Helen M., Professor of Botany and Curator of the Herbarium, *Oregon State College, Corvallis, Ore.* (Taxonomy and distribution of the Tuberales.)

Gilman, Joseph C., Professor of Botany, *Department of Botany, Iowa State College, Ames, Iowa.* (Parasitic fungi; soil fungi.)

Goldsworthy, Marion Charles, Pathologist, *U. S. Department of Agriculture Horticultural Station, Beltsville, Md.*

Goodding, Leslie N., Botanist, U. S. Department of Agriculture, retired, *Box 303, Jerome, Ariz.* (Southwestern plants and forest tree diseases.)

Gordon, Frank M., *Department of Plant Pathology, Cornell University, Ithaca, N. Y.*

Gordon, Dr. W. L., *Dominion Rust Research Laboratory, Winnipeg, Man., Canada.* (Taxonomy of Fusarium.)

Gosselin, Dr. Roger, *3 Belleau Ave., Lévis, Quebec, Canada.* (Research in wood rots of conifers.)

Gravatt, Mrs. Annie R., Technical editor, *Plant Industry Station, Beltsville, Md.* (Forest pathology; diseases of fruits, vegetables and other crops.)

Graves, Dr. Arthur H., *255 South Main St., Wallingford, Conn.* (Diseases of forest trees.)

Gray, Dr. W. D., *Department of Botany, Ohio State University, Columbus, Ohio.*

Greathouse, Dr. Glenn A., *George Washington University, 720 20th St., N.W., Washington 6, D. C.*

Greene, H. C., Curator, Cryptogamic Herbarium, *Department of Botany, University of Wisconsin, Madison 6, Wis.* (Taxonomy of parasitic fungi.)

Groves, Dr. J. W., *Division of Botany, Central Experimental Farm, Ottawa, Ontario, Canada.* (Dermateaceae; seed-borne fungi.)

Gruber, Wm. B., *6476 S. W. Burlingame Place, Portland, Ore.*

Grunberg, Emanuel, *2517 West Burnett Ave., Louisville, Ky.* (Medical mycology.)

Guiscafré-Arrillaga, J., *Department of Botany and Plant Pathology, Louisiana State University, Baton Rouge, La.*

Haenseler, Dr. C(onrad) M(artin), *Agricultural Experiment Station, New Brunswick, N. J.* (Plant pathology.)

Hahn, Dr. Glenn G., *Marsh Hall, Yale University, 360 Prospect Street, New Haven 11, Conn.* (Forest fungi; pathology and taxonomy.)

Hanna, Dr. W. F., *Dominion Rust Research Laboratory, Winnipeg, Manitoba, Canada.* (Cereal smuts; Agaricaceae.)

Hansbrough, Dr. John R., *360 Prospect St., New Haven 11, Conn.* (Forest pathology; mycology.)

Hansen, H. N., Professor of Plant Pathology, *211 Hilgard Hall, University of California, Berkeley 4, Calif.* (Variation; genetics and taxonomy of fungi.)

Hanson, Miss Ann M., *175 West 76th St., New York 23, N. Y.*

Hardison, John R., Associate Pathologist, U. S. Department of Agriculture, Division of Forage Crops and Diseases, *Oregon Agricultural Experiment Station, Corvallis, Ore.* (Diseases of forage grasses and legumes.)

Harrar, Dr. J. George, *Rockefeller Foundation, Viena 26, Mexico City, D. F., Mexico.* (Plant pathology; mycology.)

Harrison, K. A., Associate of Plant Pathology, *Laboratory of Plant Pathology, Kentville, Nova Scotia, Canada.* (Agaricales.)

HARVEY, JAMES V., Senior Biologist, *Biological Laboratories, Quartermaster Depot, 2800 So. 20th Street, Philadelphia 45, Pa.* (Phycomycetes; Saprolegniales; Pythiales; soil microorganisms.)

HASKINS, R(EGINALD) H(INTON), Teaching Fellow in Biology, *Biological Laboratories, Harvard University, 16 Divinity Ave., Cambridge 38, Mass.* (Aquatic Phycomycetes; physiology of Chytridiales.)

HATCH, DR. WINSLOW R(OPER), *Department of Botany, State College of Washington, Pullman, Wash.* (Sexuality in Phycomycetes.)

HAZEN, ELIZABETH L., *339 E. 25th St., New York, N. Y.*

HENRY, L. K., Curator of Botany, *Carnegie Museum, Pittsburgh 13, Pa.* (Taxonomy of Basidiomycetes.)

HESLER, L. R., Professor of Botany, *University of Tennessee, 101 Biology Building, Knoxville, Tenn.*

HESSELTINE, CLIFFORD W., Industrial Mycologist, *Lederle Laboratories, Inc., Pearl River, N. Y.* (Mucorales, Fungi Imperfecti.)

HILAIRE, SISTER M., *Rosary College, River Forest, Ill.*

HILBORN, M. T., Associate Plant Pathologist, *Agricultural Experiment Station, Orono, Me.* (Forest pathology; diseases of fruit trees.)

HILLEGAS, DR. ARTHUR B(URDETTE), *Research Laboratories, Parke Davis & Co., Detroit 32, Mich.* (Phycomycetes; fungi pathogenic for man; cytology.)

HIRSCHHORN, DR. ELISA, *Calle 58, No. 484, La Plata, Argentina.*

HOFFMAN, ROBERT J., *101 E. 72nd St., New York 21, N. Y.*

HONEY, DR. EDWIN E., Pathologist, *P. O. Box 12, Wausau, Wis.* (Discomycetes; Monilinia.)

HOPKINS, J. GARDNER, Emeritus Professor of Dermatology, *College of Physicians and Surgeons, 630 W. 168th St., New York 32, N. Y.* (Medical mycology.)

HOTSON, HUGH H(OWISON), *3949 15th St., N. E., Seattle, Wash.* (Mycology.)

HOUSE, HOMER D., State Botanist, *New York State Museum, Albany, N. Y.* (Taxonomy.)

HOWARD, FRANK L., Professor of Plant Pathology, Head, Department of Plant Pathology-Entomology, *Rhode Island State College, Kingston, R. I.* (Chemotherapy; fungicides; diluents.)

HOWARD, GRACE E., Associate Professor of Botany, Wellesley College, *Wellesley 81, Mass.* (Taxonomy of fungi and lichens.)

HOWELL, DR. ARDEN, JR., *T. B. Control Division, U. S. Public Health Service, Box 3536, Duke Hospital, Durham, N. C.* (Medical mycology.)

HUNT, N. REX, Retired pathologist, *Felton, Calif.* (Protection from foreign plant diseases; coordinated planning for plant protection.)

HUTCHINSON, WESLEY G., Associate Professor of Botany, *Department of Botany, University of Pennsylvania, Philadelphia, Pa.*

HWANG, DR. SHUG-WEI, *c/o K. T. Tom, Bank of China, 40 Wall St., New York 5, N. Y.*

IMLE, DR. ERNEST P., Senior Pathologist, Director U. S. Department of Agriculture Rubber Station, *U. S. Department of Agriculture Rubber Station, Turrialba, Costa Rica, C. A.* (Plant pathology; plant physiology; mycology.)

JACKSON, DR. HENRY A(LEXANDER) C(ARMICHAEL), *35 Campbell Ave., Montreal West, Quebec, Canada.*

JACKSON, DR. HERBERT S(PENCER), *Department of Botany, University of Toronto, Toronto 5, Ontario, Canada.* (Taxonomy and comparative morphology, especially of Uredinales and Thelephoraceae.)

JACQUES, DR. J(OSEPH) EMILE, *Montreal Botanical Garden, Montreal, Quebec, Canada.* (Dematiaceae; Phragmosporae.)

JENKINS, DR. ANNA ELIZA, Mycologist, *Plant Industry Station, Beltsville, Md.* (Taxonomy and comparative morphology, especially of Myriangiales and Exoascaceae; mycological history.)

JENNINGS, DR. O(TTO) E(MERY), *Carnegie Museum, Pittsburgh, Pa.* (Systematic, ecological and paleontological botany.)

JOFFILY, JOSÉ M., *Rua Terezina N. 13, (Sta. Tereza), Rio de Janeiro, D. F., Brazil.*

JOHANSON, ALFHILD E., *730 Cranford Avenue, New York 66, N. Y.* (Mycology, cytology and general botany.)

JOHNSON, AARON G., Principal Pathologist, *Bureau of Plant Industry Station, Beltsville, Md.* (Diseases of cereal crops.)

JOHNSON, DR. GEORGE T., *Department of Biology, Massachusetts Institute of Technology, Cambridge 39, Mass.*

JOHNSON, HARRY I., *South Meriden, Conn.*

JOHNSON, HOWARD W., Senior Pathologist, *Delta Branch Experiment Station, Stoneville, Miss.* (Plant pathology and mycology.)

JONES, FRED REUEL, Pathologist, *Horticulture Building, University of Wisconsin, Madison, Wis.* (Pathology of leguminous forage crops.)

JONES, MRS. JOYCE HEDRICK, *Museums Building, University of Michigan, Ann Arbor, Mich.* (Lichenology.)

JONES, RICHARD C., Assistant Professor of Botany, University of New Hampshire, *Mast Road, Durham, N. H.* (Alternation of generations; nature of sexuality; tissue culture.)

JONES, WALTER, *Plant Pathology Laboratory, Saanichton, British Columbia, Canada.* (Plant pathology.)

JØRSTAD, DR. IVAR, *Botanical Museum, Oslo, Norway.*

JUST, DR. THEO(DOR) K(ARL), *Chicago Natural History Museum, Chicago 5, Ill.* (Morphology.)

JUSTO-PRATS, RALPH, *Library, College of Agriculture and Mech. Arts, Mayaguez, Puerto Rico.*

KANOUSE, DR. BESSIE B(ERNICE), *406 South 5th Avenue, Ann Arbor, Mich.* (Phycomycetes; Discomycetes.)

KARLING, JOHN S., Professor of Botany, *Department of Botany, Columbia University, New York 27, N. Y.* (Development, morphology and phylogeny of fungi.)

KARPLUK, MRS. FRANCES E., *Mycology Department, N. Y. Skin and Cancer Unit, 330 Second Ave., New York 3, N. Y.*

KEIL, HARRY L., Plant Pathologist, Insectory, *Rohm & Haas Co., Bristol, Pa.* (Development of insecticides and fungicides.)

KEITT, GEORGE W(ANNAMAKER), Professor of Plant Pathology, Chairman of the Department, *207 Horticulture Building, University of Wisconsin, Madison 6, Wis.* (Parasitism, pathogenesis, epidemiology, genetics and physiology of pathogenic fungi; antibiotics.)

KERN, FRANK D., Professor of Botany; Dean of the Graduate School, Pennsylvania State College, *Buckhout Laboratory, State College, Pa.* (Uredinales.)

KEVORKIAN, ARTHUR G., Director, Atkins Garden & Research Laboratory, Harvard University, *Apartado # 251, Cienfuegos, Cuba.* (Tropical botany; mycology and plant pathology.)

KHAN, ABDUL H., Graduate Student, *107 Hilgard Hall, University of California, Berkeley, Calif.*

KIENHOLZ, JESS R., Associate Plant Pathologist, *U. S. Fruit Diseases Laboratory, Hood River, Ore.* (Fruit diseases.)

KING, THOMAS HENRY, Plant Pathologist, *Department of Botany, Ohio State University, Columbus 10, Ohio.* (Plant pathology and mycology.)

KOLK, LAURA A., Assistant Professor, Brooklyn College, *416 Ocean Avenue, Brooklyn 26, N. Y.* (Algae and fungi.)

KOPF, KENNETH, Geneticist, *Hawaiian Pineapple Co., Box 3380, Honolulu 1, T. H.* (Myxomycetes; interrelationships of economic fungi with hosts.)

KORF, RICHARD P(AUL), Assistant, *Department of Plant Pathology, Cornell University, Ithaca, New York.* (Taxonomy of Discomycetes, especially Hyaloscyphaceae.)

LAMBERT, DR. EDMUND B., *1217 Walnut St., Coatesville, Pa.* (Mushroom culture and diseases.)

LANGE, MORTEN, *Kongensgade 33, Copenhagen, Denmark.*

LEDINGHAM, DR. GEORGE ALECK, *Division of Applied Biology, National Research Council, Ottawa, Ontario, Canada.* (Industrial fermentations.)

LEFEBVRE, DR. C(AMILLE) L(EON), Plant Pathologist, *Plant Industry Station, Beltsville, Md.* (Diseases of forage crop plants.)

LEVINE, MICHAEL, Ph.D., Biologist, Montefiore Hospital, New York, *100 Halsted Avenue, Yonkers 4, N. Y.*

LEWIS, DR. GEORGE M., *Cornell University Medical School, 121 East 60th St., New York City.* (Medical mycology.)

LIMBER, MR. DONALD P., *3 Mayfair Road, Morris Plains, N. J.*

LINDEGREN, DR. CARL C., *Washington University, St. Louis 5, Mo.*

**LINFORD, DR. M(AURICE) B(LOOD), Pathologist, Pineapple Research Institute, *P. O. Box 3166, Honolulu 2, Hawaii.* (Plant pathology.)

LOCKWOOD, L(EWIS) B., Microbiologist, *Northern Regional Research Laboratory, Peoria 5, Ill.* (Physiology and biochemistry of fungi and bacteria; fermentation; taxonomy of Mucorales.)

LOHMAN, MARION L., Associate Professor of Botany, *Botany Department, University of Hawaii, Honolulu 10, Hawaii.* (Hysteriaceae.)

LOMBARD, MRS. FRANCES F., Assistant Pathologist, Division of Forest Pathology, U. S. Department of Agriculture, Beltsville, Md. *5301 38th Avenue, Hyattsville, Md.* (Diseases and decays of forest trees and taxonomy of fungi involved.)

LONG, DR. WILLIAM HENRY, *P. O. Box 1478, Albuquerque, New Mexico.* (Pathology and taxonomy of fungi.)

LOWE, DR. JOSIAH L(INCOLN), *College of Forestry, Syracuse University, Syracuse, N. Y.* (Lichens; Polyporaceae.)

LUCAS, GEORGE BLANCHARD, Assistant Professor in Tobacco Research, North Carolina State College Experiment Station, *Tobacco Experiment Station, Oxford, N. C.* (Plant pathology.)

LURIE, DR. H. I., *South African Institute for Medical Research, Hospital St., Johannesburg, S. Africa.*

LÜTJEHARMS, DR. W. J., Professor of Botany, *University College of the O.F.S., Bloemfontein, South Africa.* (Hyphomycetes; soil biology; physiology.)

LUTTRELL, EVERETT STANLEY, Associate Botanist, *Georgia Experiment Station, Experiment, Ga.* (Morphology of Ascomycetes.)

MCCOLLOCH, LACY P., Associate Plant Pathologist, *U. S. Department of Agriculture Plant Industry Station, Beltsville, Md.* (Diseases of fruits and vegetables in storage, transit and on the market.)

MCCREA, DR. ADELIA, *R.R. # 1, Roscommon, Mich.*

MCDONOUGH, E. S., Associate Professor, *Department of Biology, Marquette University, Milwaukee 3, Wis.*

MCFARLAND, DR. FRANK T(HEODORE), *Department of Botany, University of Kentucky, Lexington, Ky.* (Taxonomy of Hypocreales, vascular flora of Kentucky.)

MCGUIRE, J. M., Head, Department of Microbiology, *Eli Lilly & Co., Lilly Research Laboratories, Indianapolis, Indiana.* (Antibiotics.)

MCKENZIE, DR. MALCOLM A(RTHUR), *Clark Hall, Massachusetts State College, Amherst, Mass.* (Forest pathology.)

MACEO, MRS. JOSEPHA VELAZQUEZ, *University of Puerto Rico, Rio Piedras, P. R.*

MACRAE, DR. RUTH, *Division of Botany, Central Experimental Farm, Ottawa, Ontario, Canada.* (Wood-destroying Hymenomycetes.)

**MAINS, EDWIN B., Professor of Botany, Director of the Herbarium, *University of Michigan, Ann Arbor, Mich.* (Uredinales; entomogenous fungi; *Hydnum.*)

MANEVAL, DR. W(ILLIS) E(DGAR), *305 Westmount Ave., Columbia, Mo.* (Plant pathology and mycology.)

MARSHALL, DR. RUSH P(ORTER), *Bartlett Tree Research Laboratories, Stamford, Conn.* (Shade tree diseases.)

MARTIN, G(EORGE) W(ILLARD), Professor of Botany, *State University of Iowa, Iowa City, Iowa.* (Myxomycetes; Heterobasidiomycetes; tropical fungi.)

MASON, E. W., *Imperial Institute of Mycology, Ferry Lane, Kew, Surrey, England.* (Pyrenomycetes.)

MASSEY, DR. L. M., *Department of Plant Pathology, College of Agriculture, Cornell University, Ithaca, N. Y.* (Plant pathology.)

MATTHEWS, VELMA DARE, Professor of Biology, *Coker College, Hartsville, S. C.* (Phycomycetes.)

MECKSTROTH, GUSTAV A., Associate Pathologist, *U. S. Department of Agriculture, 415 N. Parramore St., Orlando, Fla.* (Storage and transportation diseases of citrus and other fruits and vegetables.)

MEINECKE, DR. E(MILIO) P(EPE), *3157 Jackson St., San Francisco 15, Calif.* (Forest pathology.)

MIELKE, JAMES L., Pathologist, *P. O. Box 523, Albuquerque, N. Mex.* (Forest pathology.)

MILLER, DR. JOSEPH A., *364 Prospect St., South Orange, N. J.*

MILLER, DR. JULIAN H., *Department of Plant Breeding and Plant Pathology, University of Georgia, Athens, Ga.* (Pyrenomycetes, especially Sphaeriales.)

MILLER, DR. L. WALLACE, Professor of Biology, *Department of Biology, Illinois State Normal University, Normal, Illinois.* (Hydnaceae.)

MILLER, PIERRE A., Associate Professor of Plant Pathology; Associate Plant Pathologist, Experiment Station, *U.C.L.A., 405 Hilgard Ave., Los Angeles 24, Calif.* (Diseases of landscape plants; diseases of subtropical fruit plants.)

MIX, DR. A. J., Professor of Botany, *University of Kansas, Lawrence, Kans.* (Taphrinales; lower Ascomycetes; fungi pathogenic to man; physiology of fungi.)

MOLINE-LLARDEN, MARIO, *Department of Plant Pathology, Cornell University, Ithaca, N. Y.*

MONTGOMERY, DR. ROYAL M., *57 West 57th St., New York 19, N. Y.* (Dermatology; medical mycology.)

MOORE, DR. GEORGE T., Director, *Missouri Botanical Garden, St. Louis, Mo.*

MOORE, DR. MORRIS, Mycologist to the Barnard Free Skin and Cancer Hospital, to Barnes Hospital, and to Washington University School of Medicine, *Barnard Free Skin and Cancer Hospital, St. Louis, Mo.* (Medical mycology.)

MORGAN-JONES, JOHN F., *Department of Biology, Mount Allison University, Sackville, New Brunswick, Canada.* (Physiology of the mildews, especially *Erysiphe graminis Hordei.*)

MORROW, DR. MARIE BETZNER, *Department of Botany and Bacteriology, University Station, Austin, Tex.* (Soil fungi; molds in the etiology of respiratory allergic diseases.)

MORSE, MISS ELIZABETH EATON, *Hotel Claremont, Berkeley 5, Calif.* (Western fungi; Gasteromycetes.)

MOSS, DR. EZRA HENRY, Professor of Botany, *University of Alberta, Edmonton, Alberta, Canada.* (Uredinales.)

MRAK, EMIL M., Associate Professor and Associate Mycologist in the Experiment Station, *339 Hilgard Hall, University of California, Berkeley 4, Calif.* (Yeasts.)

MUIR, DR. ROBERT D., *Box 657, Syracuse, N. Y.*

MÜLLER, DR. ALBERT S., *Escuela Nacional de Agricultura, Barcena, Villa Nueva, Guatemala, C. A.* (Mycology and plant pathology.)

MUNDKUR, DR. B(HALCHENDRA) B., *Imperial Agricultural Research Institute, New Delhi, India.* (Smuts; virus diseases of the potato; mycological literature.)

NANNFELDT, DR. JAN A., *Uppsala Universitets Inst., Systematisk Botanik, Uppsala, Sweden.*

NAUSS, RUTH N., Technician, *1303 York Ave., Apt. 2H, New York 21, N. Y.* (Myxomycetes.)

NICKERSON, WALTER J(OHN), JR., *c/o Dr. G. A. Edwards, Department of Biology, Tufts College, Medford, Mass.* (Physiology of fungi; physiology of sex in fungi; taxonomy and physiology of yeasts.)

NIEDERHAUSER, JOHN S., *c/o Rockefeller Foundation, Calle Viena 26, Mexico, D. F., Mexico.*

NOBLES, DR. MILDRED K., Assistant Plant Pathologist, *Division of Botany and Plant Pathology, Central Experimental Farm, Ottawa, Ontario, Canada.* (Cultural studies of wood-rotting fungi.)

OCHOA, DR. A. GONZALEZ, *Laboratorio de Micologia, Instituto de Salubridad y Enfermedades Tropicales, Mexico, D. F.*

OLIVE, DR. LINDSAY S., Associate Professor of Botany, *Department of Botany, Bacteriology, and Plant Pathology, Louisiana State University, Baton Rouge, La.* (Mycology; plant pathology.)

ORONOZ, DR. MANUEL RUIZ, *Calle de Reynosa #56, Tacubaya, Mexico, D.F., Mexico.* (Mosses; lichens; hepatics; fungi.)

ORTON, DR. C. R., Dean and Director, College of Agriculture, Forestry, and Home Economics; Agricultural Experiment Station, *University of West Virginia, Morgantown, W. Va.* (Rusts and Ascomycetes.)

OVERHOLTS, MRS. L. O., *7442 Trevanion St., Pittsburgh 18, Pa.* (Taxonomy of the Agaricaceae; field natural history.)

PADY, STUART M., Associate Professor of Botany, *McGill University, Montreal 2, Quebec, Canada.* (Uredinales; cytology.)

PAGE, ROBERT M., Junior Research Fellow, National Institute of Health, *Biological Laboratories, 16 Divinity Ave., Cambridge 38, Mass.* (Physiology of fungi.)

PARKER, DR. CHARLES S(TEWART), *Department of Botany, Howard University, Washington, D. C.* (Taxonomy; Basidiomycetes.)

PARKS, HAROLD E., Associate Curator, University of California, "*Spruce Cove*," *Trinidad, Calif.* (Hypogaei; Uredinales; Discomycetes.)

PAULSEL, DONALD P., *Base Unit, Tyndall Field, Fla.*

PAYETTE, ALBERT, Junior Plant Pathologist, *Sainte Anne-de-la-Pocatière, Quebec, Canada.* (Fungi causing leaf spots on trees, etc.)

PEASE, DOROTHY, Brooklyn College, *Department of Biology, Bedford & Ave. H, Brooklyn 10, N. Y.*

PETERSEN, MISS GRACE (AGNES), *8511 110th St., Richmond Hill 18, N. Y.* (Lichens.)

PETTY, DR. MILTON A. JR., Mycologist, *Lederle Laboratories Division, American Cyanamid Co., Pearl River, N. Y.* (Production of antibiotics; Industrial Fermentations; genetics of fungi; plant pathology.)

PLAKIDAS, A(NTONIOS) G(EORGE), Plant Pathologist and Professor of Botany, *Louisiana State University, Baton Rouge, La.* (Plant pathology; diseases of ornamental plants.)

PLUNKETT, ORDA A(LLEN), *U.C.L.A., 405 Hilgard Ave., Los Angeles, Calif.* (Mycology; plant pathology; medical mycology.)

POLLACK, MRS. FLORA G., Associate Mycologist, *4300 Russell Ave., Mt. Rainier, Md.* (Fungi Imperfecti.)

POMERLEAU, DR. RENÉ, Director, Division of Forest Pathology, *Department of Lands and Forests, Quebec, Que., Canada.* (Taphrina; Polyporaceae.)

POOLE, DR. ROBERT FRANKLIN, President, Clemson College, *Clemson, S. C.*

POPE, SETH, Senior Mycologist, *Schenley Laboratories, Lawrenceburg, Ind.* (Physiology of fungi; fermentation; antibiotics.)

PORTER, DR. CHARLES L(YMAN), Purdue University, *924 N. Main St., West Lafayette, Ind.* (Plant pathology.)

POTTER, VICTOR C., *221 N. Elm St., Ithaca, N. Y.*

POUND, DR. ROSCOE, University Professor, Emeritus, *Harvard Law School, Cambridge, Mass.* (Parasitic fungi.)

POVAH, DR. ALFRED H., Science Teacher, Denby High School, *143 Elmhurst Ave., Detroit 3, Mich.*

PRASAD, NIRANKAR, Graduate Student, *Division of Plant Pathology, University of California, Berkeley, Calif.*

PRESLEY, JOHN T., Pathologist and Head of the Department of Plant Pathology, *Box 333, State College, Miss.* (Plant pathology.)

PRINCE, DR. ALTON E., Assistant Professor of Botany, *Department of Botany, University of Maine, Orono, Me.* (Erysiphaceae.)

RADER, WILLIAM E., Plant Pathologist, *Shell Agricultural Laboratory, Modesto, Calif.* (Physiology of the fungi; morphology and taxonomy of the Pyrenomycetes.)

RAPER, DR. KENNETH B., Principal Microbiologist, *Northern Regional Research Laboratories, U. S. Department of Agriculture, Peoria, Ill.* (Fermentative molds; Myxomycetes; aspergillaceae; antibiotic production by microorganisms.)

RAY, W(ILLIAM) W(INFIELD), Professor of Botany and Experiment Station Mycologist, *Department of Botany, University of Nebraska, Lincoln 8, Neb.* (General mycology; Taphrinales; diseases of cotton.)

REA, PAUL M., *436 E. Padre Street, Santa Barbara, Calif.* (Fungi of Southern California.)

REBELL, DR. G. C., *Dept. of Dermatology and Syphilology, School of Medicine, University of Pennsylvania, Philadelphia, Pa.*

REED, DR. GEORGE M., *25 So. Linwood Ave., Pittsburgh 5, Pa.* (Cereal smuts; environmental factors and host infection; genetics of resistance).

REESE, DR. E(LWYN) T(HOMAS), *Shimer Blvd., Phillipsburg, N. J.*

REISCHER, HELEN S., Student, Columbia University, *23–03 44th Drive, Long Island City 1, N. Y.*

RHOADS, DR. ARTHUR S., *Prevention of Deterioration Center, National Research Council, 2101 Constitution Ave., Washington 25, D. C.*

ROBERTS, DR. CATHERINE, *Carlsberg Laboratorium, Copenhagen, Denmark.* (Yeasts and yeast-like fungi; variation in fungi.)

ROBERTS, DR. JOHN MAURICE, Mycologist in Antibiotic Research, *Bureau of Laboratories, Michigan Department of Health, Lansing 4, Mich.* (Antibacterial substances; cytology of chytrids.)

ROBERTS, DR. JOHN W., Principal Pathologist, U. S. Department of Agriculture, Bureau of Plant Industry (retired), *116D Park Ave. S., Winter Park, Fla.* (Leaf spore fungi.)

ROBLIN, DR. R. O., *Stamford Laboratories, American Cyanamid Co., Stamford, Conn.*

RODRIGUEZ, ING. JOSÉ V., Oficina de Estudios Espéciales, *Direc. Gral. de Agricultura, San Jacinto, D. F., Mexico.*

ROGERS, DONALD P(HILIP), Curator, *New York Botanical Garden, Bronx Park, Fordham Branch P. O., New York 58, N. Y.* (Cytology, comparative morphology, and taxonomy of the lower Basidiomycetes.)

ROGERSON, CLARK T., *Department of Plant Pathology, Cornell University, Plant Science Building, Ithaca, N. Y.*

ROSEN, H(ARRY) R(OBERTS), *Merck & Co., Rahway, N. J.* (Pathology of cereal crops, roses, etc.)

ROTH, LEWIS F., Associate Professor, *Department of Botany and Plant Pathology, Oregon State College, Corvallis, Ore.* (Hypodermataceae, aquatic fungi, Discomycetes.)

ROUTIEN, JOHN B., Mycologist, *Chas. Pfizer & Co., 11 Bartlett St., Brooklyn 6, N. Y.* (Genetics and biochemistry of fungi; Agaricaceae.)

RUDOLPH, DR. BERT A., University of California Deciduous Fruit Station, *2675 Stevens Creek Road, San José, Calif.* (Plant pathology.)

RUEHLE, GEO(RGE) D(EWEY), Vice-Director-in-Charge, *Sub-Tropical Experiment Station, Rt. 2, Box 508, Homestead, Fla.* (Improvement of tropical fruits; potato diseases; tomato diseases.)

RUSDEN, DR. PHILIP L., *206 Federal Building, Central Square, Cambridge, Mass.* (Cytology; Phycomycetes; Gasteromycetes.)

RYAN, SISTER MARY HILAIRE, O.P., Ph.D., *Rosary College, River Forest, Ill.*

SAKSENA, DR. RAM KUMAR, *Department of Botany, University of Allahabad, Allahabad, India.*

SALVIN, SAMUEL B., *National Institute of Health, Bethesda, Md.* (Medical mycology.)

SANFORD, MRS. AUGUSTA LEUCHS, *Round Hill Road, Greenwich, Conn.*

SANTACROCE, NUNZIO GEORGE, *525 Caswell Ave., Staten Island 2, N. Y.*

SAVILE, D(OUGLAS) B. O., *Division of Botany and Plant Pathology, Central Experimental Farm, Ottawa, Ontario, Canada.* (Taxonomic plant pathology; cytology of fungi.)

SCHNEIDERMAN, BENJ., *Centro Research Laboratories, Inc., Water St., Ossinings, N. Y.*

SCULLY, DR. FRANCIS J., *904 Medical Arts Building, Hot Springs, Ark.* (Amateur interest in taxonomic botany.)

SEAVER, DR. FRED JAY, Head Curator and Managing Editor of Mycologia, *The New York Botanical Garden, Bronx Park 58, New York.* (Discomycetes.)

SEELER, EDGAR V., Farlow Herbarium, *20 Divinity Ave., Cambridge, Mass.*

SHAFFER, DR. NATHAN, *Army-Navy General Hospital, Hot Springs National Park, Ark.*

SHANOR, DR. LELAND, Assistant Professor of Botany, *University of Illinois, Urbana, Ill.* (Aquatic Phycomycetes; Ascomycetes; plant disease fungi.)

SHAW, CHARLES GARDNER, Instructor in Plant Pathology, *Plant Pathology Department, Washington State College, Pullman, Wash.* (Peronosporales; Forest Pathology.)

SHEAR, DR. C(ORNELIUS) L(OTT), *2253 N. Madison St., Arlington, Va.* (Taxonomy of Pyrenomycetes.)

SHEMA, BERNARD F., Research Assistant, *316 E. McKinley, Appleton, Wis.* (Mycology as applied to the pulp and paper industry.)

SHERBAKOFF, DR. C(ONSTANTINE) D., *Agricultural Experimental Station, University of Tennessee, Knoxville, Tenn.* (Diseases of wheat, cotton, red clover, tomatoes, strawberries; the genus Fusarium.)

SHIMP, HELENE NUSSLE, *Walnut, Ill.* (Morchella; edible mushrooms.)

SHOTTS, HELEN G., *5255 Larchwood Avenue W., Philadelphia 43, Pa.*

SHOUP, DR. CHARLES S., Associate Professor of Biology, *Department of Biology, Vanderbilt University, Nashville 4, Tenn.* (Cell physiology; respiration.)

SILVEIRA, VERLANDE D., *Rua Visconde de Piraja, 583 C. 1., Ipanema, Rio de Janeiro, Brazil, S. A.*

SIMMONS, EMORY G., Teaching Fellow in Botany, *Department of Botany, University of Michigan, Ann Arbor, Mich.* (Ascomycetes.)

SIMSON, FRANK W., *427 Currie Road, Durban, Natal, S. Africa.*

SINDEN, DR. JAMES W., Department of Botany, *Pennsylvania State College, State College, Pa.* (Commercial mushrooms; physiology of fungi.)

SINGER, DR. ROLF, Farlow Herbarium, *Harvard University, 20 Divinity Ave., Cambridge 38, Mass.* (Taxonomy of the Agaricales.)

SKINNER, DR. CHARLES E., Associate Professor, *Department of Bacteriology, University of Minnesota, Minneapolis 14, Minn.* (Yeasts; Actinomycetes; medical mycology.)

SKOLO, DR. A. J., Forest Pathologist, *Dominion Laboratory of Forest Pathology, Fredericton, N. B., Canada.*

SLAGHT, DR. HELEN B., *4801 Connecticut Ave., N.W., Washington 8, D. C.* (Phycomycetes.)

SLEETH, DR. BAILEY, *U. S. Department of Agriculture, Bureau Plant Industry, Box 102, Raymondville, Texas.* (Forest and guayule pathology.)

SLIPP, ALBERT W., Assistant Professor of Forest Pathology, *School of Forestry, University of Idaho, Moscow, Idaho.* (Forest pathology; ecology of forest fungi; ecology of fungi in general.)

SMART, ROBERT FORTE, Professor of Biology and Chairman of the Department of Biology, *University of Richmond, Richmond, Va.* (Myxomycetes; cytology of Ascomycetes.)

SMITH, LT. ALBERT G., *c/o Geo. Oehler, R.F.D. 7, Knoxville, Tenn.*

SMITH, DR. ALEXANDER H., Associate Curator of Fungi, Editor in chief of Mycologia; Herbarium, *Museums Building, University of Michigan, Ann Arbor, Mich.* (Cytology and taxonomy of Agaricaceae.)

SNELL, WALTER HENRY, Stephen T. Olney Professor of Natural History, *Brown University, Providence 12, R. I.* (Boletaceae; pileate Hydnaceae.)

SNYDER, DR. WILLIAM C., *107 Hilgard Hall, University of California, Berkeley 4, Calif.* (Taxonomy of Fusarium; vegetable pathology.)

SOLHEIM, DR. W(ILHELM) G(ERHARD), *Department of Botany, University of Wyoming, Laramie, Wyo.* (Rocky Mountain fungi; Hyphomycetes.)

SPARROW, DR. FREDERICK K., Associate Professor of Botany, *University of Michigan, Ann Arbor, Mich.* (Aquatic fungi; aquatic flowering plants.)

SPRAGUE, DR. RODERICK, Associate Professor, *Department of Plant Pathology, Washington State College, Pullman, Wash.* (Leafspots and root rots of Gramineae.)

SPRINGER, DR. MARTHA E(DITH), *Department of Botany, Willamette University, Salem, Ore.* (Aquatic Phycomycetes.)

STAKMAN, DR. E(LVIN) C., *University Farm, St. Paul, Minn.* (Plant pathology; mycology.)

STANLEY, MISS INA N., *917 E. 46th St., Indianapolis, Ind.*

STEVENS, NEIL E(VERETT), *Department of Horticulture, University of Illinois, Urbana, Ill.*

STEVENS, DR. RUSSELL B., Associate Professor of Botany, *University of Tennessee, Knoxville, Tenn.* (Plant diseases; pathogenic fungi.)

STEVENSON, JOHN A., Principal Mycologist, Division of Mycology and Disease Survey, *Plant Industry Station, Beltsville, Md.* (Taxonomy of the fungi.)

STEWART, DR. IRENE M., *3198 Travers Ave., Hollyburn, British Columbia, Canada.* (Forest mycology; seed-borne diseases.)

STIFLER, MRS. CLOYD BURNLEY, *315 16th St., Bradenton, Fla.*

STILLINGER, C. R., *418 College Avenue, Moscow, Idaho.*

STOUFFER, DAVID J., Range Examiner, *Safford, Ariz.* (Puffballs; forest pathology.)

STRONG, MRS. MIRIAM C., Research Assistant in Plant Pathology, Department of Botany, Michigan State College, *1213 N. Walnut St., Lansing, Mich.* (Fusaria; tomato disease pathogens.)

STUNTZ, D(ANIEL) E(LLIOT), *Department of Botany, University of Washington, Seattle, Wash.* (Agaricaceae.)

SUMSTINE, DR. DAVID R., Research Associate in Botany, Carnegie Museum, *4601 Bayard St., King Edward Apts., Pittsburgh 13, Pa.* (Taxonomy of fungi; Hyphomycetes.)

SUTTON, W. D., *313 Wharncliffe Road N., London, Ontario, Canada.* (Taxonomy.)

SWARTZ, DR. DELBERT, *Box 93, University Station, Fayetteville, Ark.* (Comparative morphology of Lycoperdaceae.)

SWARTZ, DR. JACOB HYAMS, *371 Commonwealth Ave., Boston, Mass.* (Medical mycology and dermatology.)

SWEET, DR. HERMAN R., Assistant Professor in Biology, *Tufts College, Medford, Mass.* (Physiology of fungi; cellulose-destroyers.)

TEHON, DR. LEO R(OY), Head, Section of Applied Botany and Plant Pathology, *Illinois State Natural History Survey Urbana, Ill.* (Lophodermium; economic mycology in Illinois; Illinois flora.)

TERVET, IAN, *Camp Detrick, Md.*

TETER, HAROLD E., *15866 MacArthur St., Detroit 23, Mich.* (Phycomycetes; sexuality of aquatic fungi.)

THIRUMALACHAR, M(ANDAYAM) J(EERSANNIDHI), *20th V Main Road, Malleswaram, Bangalore, India.*

THOM, CHARLES, *207 Grant St., Port Jefferson, N. Y.* (Mycology, industrial microörganisms; Penicillium; Aspergillus, etc.)

THOMPSON, DR. GEORGE E(DWARD), Department of Plant Pathology, *College of Agriculture, University of Georgia, Athens, Ga.* (Forest pathology; general mycology.)

THURSTON, DR. H. W., Department of Botany, *Pennsylvania State College, State College, Pa.*

TIFFNEY, WESLEY N., Professor of Biology, General College, Boston University, *35 Cottage St., Sharon, Mass.* (Mycology; Phycomycetes.)

TORREY, G(EORGE) SAFFORD, *R.F.D. 2, Eagleville, Conn.* (Intestinal fungi of arthropods)

TUCKER, DR. C. M., Professor of Botany, *University of Missouri, Columbia, Mo.* (Phycomycetes; plant pathology.)

TULLIS, DR. EDGAR C., *P. O. Box 2967, Beaumont, Tex.* (Rice diseases.)

UMANZIO, CARL BEEMAN, Professor of Bacteriology and Public Health, *77 Ramshead Road, Medford 55, Mass.* (Medical mycology.)

VAN DER LAAN, H. F., *4900 Wharton St., Galveston, Tex.*

VANTERPOOL, T(HOMAS) C(LIFFORD), *Department of Biology, University of Saskatchewan, Saskatoon, Saskatchewan, Canada.* (Root rots of cereals, particularly those caused by Pythium; flax diseases.)

VERMILION, M(ONROE) T(HOMAS), Ohio University; *Earich Road, R.D. 3, Athens, Ohio.*

Wagener, Dr. Willis W., Senior Pathologist, U. S. Department of Agriculture, *720 Appraiser's Building, San Francisco 11, Calif.*

Waksman, Dr. Selman A., *New Jersey Agricultural Experiment Station, Rutgers University, New Brunswick, N. J.* (Soil mycology; Actinomycetes; physiology of fungi; production of antibiotic substances by microorganisms.)

Walker, Dr. A(nson) R(obertson), Professor of Plant Pathology, *Department of Botany, University of Western Ontario, London, Ontario, Canada.* (Comparative morphology.)

Walker, Dr. Leva B(elle), Associate Professor, Emeritus, University of Nebraska, *1325 North 38th St., Lincoln, Neb.* (Morphology of fungi.)

Walter, James M., *2410 16th Ave., Bradenton, Fla.*

Walters, Maurice B., *14556 Superior Road, Cleveland Heights 18, Ohio.* (The fleshy fungi.)

Waterman, Dr. Alma M(ay), *Marsh Hall, 360 Prospect St., New Haven, Conn.* (Diseases of shade and ornamental trees.)

Waterston, J. M., Senior Botanist, *Department of Agriculture, Moor Plantation, Ibadan, Nigeria, B.W.A.* (Mycology; plant pathology.)

Weaver, Elmer A., *7435 Boyer Street, Philadelphia 19, Pa.*

Weber, Dr. George F(rederick), *University of Florida, Gainesville, Fla.* (Parasitic fungi; taxonomy.)

Wegrich, Dr. O. G., Mycologist, *Commercial Solvents Corporation, Terre Haute, Ind.* (Fungous genetics.)

Wehmeyer, Dr. Lewis E., Professor of Botany, University of Michigan, *381 Orchard Hill Drive, Ann Arbor, Mich.* (Pyrenomycetous fungi.)

Weidman, Fred D., Professor of Research in Dermatology and Mycology, *Medical Laboratories, University of Pennsylvania, 36th St. & Hamilton Walk, Philadelphia 4, Pa.* (Dermatology; mycology.)

Weiss, Dr. Freeman A., Senior Pathologist, *Plant Industry Station, Beltsville, Md.*

Welch, Dr. Donald Stuart, *N. Y. State College of Agriculture, Cornell University, Ithaca, N. Y.* (Taxonomy of Pyrenomycetes and Polyporaceae; forest pathology.)

Wellman, Dr. F(rederick) L(ovejoy), *Office of Foreign Agricultural Relations, U. S. Department of Agriculture, Washington, D. C.*

Wernham, Dr. Clifford Charles, Associate Professor of Plant Pathology, *Department of Botany, Pennsylvania State College, State College, Pa.* (Genetics of fungi; physiology of spore production.)

West, Dr. Erdman, Botanist and Mycologist, Florida Agricultural Experiment Station; Professor of Botany, University of Florida, *College of Agriculture, 101 Newell Hall, University of Florida, Gainesville, Fla.* (Florida Myxomycetes; Florida rust fungi.)

**Weston, Dr. Wm. H. Jr., Professor of Biology, *Biological Laboratories, Harvard University, 16 Divinity Ave., Cambridge 38, Mass.* (Aquatic fungi; Phycomycetes; fungi in relation to man.)

Whiffen, Dr. Alma J(oslyn), Mycologist, *Research Laboratories, The Upjohn Company, Kalamazoo, Mich.* (Physiology of the fungi; antibiotics.)

WHITE, DR. W. LAWRENCE, Senior Mycologist, *U. S. Army Quartermaster Corps Biological Laboratories, 2800 South 20th St., Philadelphia 45, Pa.* (Fungi of importance in industry, antibiotics, and the deterioration of industrial and military materials.)

WILHELM, STEPHEN, Research Assistant in Plant Pathology, *Division of Plant Pathology, University of California, Berkeley 4, Calif.* (Plant Pathology; pathogenic soil fungi; mycology.)

WILSON, CHARLES M., *121 Poplar Ave., Norfolk 6, Va.*

WOLF, DR. FREDERICK A., Professor of Botany, *Duke University, Durham, N. C.*

WOLF, DR. FRED(ERICK) T(AYLOR), *Botany Department, Vanderbilt University, Nashville, Tenn.* (Phycomycetes.)

WOLFE, LLOYD R., *476 Park Avenue, Glencoe, Ill.* (Mycology; botany.)

WOLFF, MISS EMILY T(OWER), *139 N. Highland Road, Springfield, Pa.* (Commercial problems involving plant materials referred to the microscopy laboratory.)

WOOD, JOHN L., *Penn State Forest School, Mount Alto, Pa.*

WOOLLIAMS, DR. G(EORGE) E(WART), *Laboratory of Plant Pathology, Summerland, British Columbia, Canada.* (Taxonomy; pathology.)

WRIGHT, C(HARLES) M(ILTON), *Department of Plant Pathology, Cornell University, Ithaca, N. Y.*

YARWOOD, DR. C. E., Associate Professor of Plant Pathology, *University of California, Berkeley, Calif.* (Powdery mildews; downy mildews; rusts.)

YUSEF, HASAN M., *The New York Botanical Garden, Bronx Park, New York City 58, N. Y.* (Physiology of fungi.)

ZABEL, ROBERT A., *New York State College of Forestry, Syracuse University, Syracuse, N. Y.*

ZELLER, DR. S(ANFORD) M(YRON), Plant Pathologist, *Oregon Agricultural Experiment Station, Oregon State College, Corvallis, Ore.* (Parasitic fungi and Gasteromycetes.)

ZIEGLER, ARTHUR WILLIAM, Instructor in Botany, University of North Carolina, *Box 602, Chapel Hill, N. C.* (Saprolegniaceae.)

ZIFFER, JACK, Research Fermentation Chemist, *A. E. Staley Co., Decatur, Ill.* (Fermentation research; antibiotic research; microbial enzymes; biochemistry of microörganisms; utilization of agricultural and industrial by-products.)

ZUCK, DR. ROBERT K., *Department of Botany, Drew University, Madison, N. J.*

ZUNDEL, DR. GEORGE LORENZO INGRAM, Associate Professor, Agricultural Extension, *Pennsylvania State College, State College, Pa.* (Smuts.)

DECEASED MEMBERS

R. A. HARPER
RALPH JUSTO-PRATS
D. H. LINDER
L. O. OVERHOLTS

CONSTITUTION AND BY-LAWS

CONSTITUTION

Art. 1. Name. The Society shall be known as the Mycological Society of America.

Art. 2. Membership.

(1) The Society shall consist of members and may include life members, patrons, honorary members, and corresponding members.

(2) Charter membership in the Society shall consist of the persons who, after the invitation of the Secretary, joined before or during the formal organization of the Society at the Atlantic City meetings in 1932.

Art. 3. Dues. The dues for regular members shall be five dollars a year. Any member may become a life member by paying one hundred dollars in one payment, or a patron by paying one thousand dollars, and upon election shall have all the privileges of members. Such funds obtained from life members and patrons shall constitute an endowment fund to be used as may be decided by the Council for the support of mycological publications or projects.

Annual dues of five dollars shall include subscription to the official organ of the Society, and shall be payable in advance on or before December 20. Bills for dues shall be sent to the members in October and it will be necessary to discontinue sending the journal to those whose dues have not been paid by December 20.

Art. 4. Membership and Election of Members.

(1) All persons interested in the study of the fungi shall be eligible to membership.

(2) Members may be elected at any regular meeting of the Society or in the interim between meetings may be elected by the Council. Application for membership must be endorsed by at least one member of the Society.

Art. 5. Officers. The officers of the Society shall consist of a President, Vice-President, and Secretary-Treasurer, whose duties shall be those usually performed by such officers. The President and Vice-President shall serve for one year and the Secretary-Treasurer for three years (or until their successors are elected). Any vacancies occurring in the interim between elections shall be filled by the Council.

The Council shall consist of the President, Vice-President, Secretary-Treasurer, and four Councilors. The Councilors shall be elected, two each year, to serve a term of two years. Two of the councilors shall be from east of the Mississippi (Minnesota is counted as west of the Mississippi) and two west. An individual may not hold two or more positions on the Council at one time.

The Council shall name a Historian to serve for an indeterminate period of years. It shall be the duty of the Historian to accumulate and preserve facts, papers, photographs, and other materials pertinent to a permanent historical record of the Society. The Historian shall not become a member of the Council by virtue of his office as Historian.

Art. 6. Editors and Committees. The editors of the official journal of the Society shall be elected by the Council. The President shall appoint all temporary committees that are to serve during his administration and shall fill all vacancies on standing committees that may occur during his term of office.

Art. 7. Election of Officers. The Secretary-Treasurer shall send to each member of the Society in October a ballot for the nomination of officers. If any nominations are lacking, the Council shall have power to make them. The three candidates for each office receiving the highest number of nominating votes shall be placed upon a final ballot to be sent to each member December 1. Should the nominating votes received by a candidate place him among the highest three for more than one office, his name shall appear on the final ballot for only the highest office. The offices rank in the order given in article 5. Votes shall be mailed to the Secretary-Treasurer and counted by the Council. A plurality vote shall elect.

Art. 8. Meetings. An annual meeting shall be held at such time and place each year as the Council may select (usually in connection with the A.A.A.S. meetings). An additional meeting for informal discussion and the carrying out of collecting forays shall be held in the summer or autumn at a time to be selected by the Council. Additional meetings, including special or local meetings for the presentation of papers or the carrying out of forays, may be arranged by the Council at its discretion.

Art. 9. Divisions. Branch organizations or units within the Society, known as Divisions, may be established on a geographical basis provided formal application, setting forth the reasons for the establishment of the Division, is made to the parent Society and approved by it.

Art. 10. Journal. The Society shall adopt or establish a journal which shall serve the Society as its official organ primarily for the publication of mycological papers by its members, for the publication of abstracts of the papers delivered at the annual or other meetings, and for the publication of the report of the Auditing Committee or of other reports, announcements, and business of the Society.

Art. 11. Amendments. These articles may be amended by a majority vote of the members voting at any regular meeting of the Society, provided that suggested amendments have been brought to the attention of the Council of the Society in time to be sent to all of the members at least one month previous to the meeting.

BY-LAWS

1. Programs. Programs for annual or other meetings shall be arranged by the Council.

2. Papers. Members wishing to present papers at the annual meeting shall submit to the Secretary-Treasurer the substance and conclusions of the papers in a clear and concise abstract of not more than 200 words. These shall be due on or before November 15, and the Secretary-Treasurer shall be authorized to refuse any received after that date. These abstracts will be edited by the editorial committee of the official journal of the Society for subsequent publication in that organ. Members are urged not to submit titles or abstracts unless they expect to attend the meetings. Except by invitation no member shall offer more than two papers at any one meeting, papers of joint authorship being attributed to the author reading the paper.

3. *Associates.* Students and others not yet members of the Society may attend meetings and forays in the status of Associates, provided they are recommended to the Council by a member of the Society and pay a fee of one dollar. Such Associates, as they are not members, shall not have the privilege of voting and shall not receive the official journal of the Society, but shall enjoy the other privileges of the meetings and forays including the right to present one paper on the program.

4. *Auditing.* At each annual meeting the active President shall appoint an auditing committee to audit the accounts of the Society and of its official publication. An audited statement shall be published in the official organ of the Society.

5. *Use of the Society's name.* Unauthorized use of the name of the Mycological Society of America for advertising or other business ventures is prohibited. The circulation of any unauthorized literature shall be taken as prima facie evidence of the violation of the intent and purpose expressed in this by-law, and the member, after being properly notified, may be expelled from the Society by a majority vote of either the Society at its meetings, or by a majority vote of the Council.

6. *These rules may be amended* by a majority vote of the members voting at any regular meeting of the Society, provided that suggested amendments have been brought to the attention of the Council of the Society in time to be sent to all the members at least one month previous to the meeting.

CONTRACT WITH THE NEW YORK BOTANICAL GARDEN

The Mycological Society of America hereby adopts *Mycologia* as its official organ on the following terms:

1. *Mycologia* will continue to be published by the New York Botanical Garden, the editorial policies to be determined by an Editorial Board, consisting of a Managing Editor appointed by the New York Botanical Garden, and five Editors elected by the Mycological Society of America. The term of office of the five elected editors will be five years, except that at the start they will be designated to serve one to five years respectively. One editor will be elected annually, thereafter, to fill the place of each retiring editor.

The six members of the Editorial Board will elect an Editor-in-Chief for a term of five years, subject to the approval of the Council of the Society and the Administration of the New York Botanical Garden. He will be eligible for repeated reëlection. Final decision of all questions on editorial policy will be made by him, except that the Managing Editor will have full authority in all matters pertaining to the finances of the journal.

2. All personal subscribers now receiving *Mycologia* may become members of the Mycological Society of America if they so desire. Institutional subscribers to *Mycologia* are not to be regarded as members of the Society.

3. All members of the Mycological Society of America in good standing will receive *Mycologia*. In return the Society will transmit to the New York Botanical Garden, through the Managing Editor, four dollars per year for each such member.

4. The New York Botanical Garden agrees to spend on the publication and distribution of *Mycologia* all funds received from subscriptions, as well as all funds transmitted by the Mycological Society of America. The Garden further agrees to use for these purposes all sums received from the sale of those volumes of the journal which shall be published after this contract is put in force. Earlier volumes remain the property of the New York Botanical Garden. It is understood that the journal will be used by the Garden for exchange purposes as formerly. Should the contract be terminated, it is agreed by the Mycological Society of America that all excess stock of *Mycologia* then on hand will be regarded as the property of the New York Botanical Garden.

5. The New York Botanical Garden reserves the fourth cover page to be used without charge for the advertisement of its publications, including *Mycologia*. The other three cover pages will be used by the Mycological Society of America as it may see fit. All sums collected from paid advertising will be expended on the journal.

6. This contract may be altered at any time by mutual agreement of the New York Botanical Garden and the Mycological Society of America. It may be terminated at the end of any calendar year on six months written notice should it prove unsatisfactory to either party concerned.

7. The contract goes into effect at the beginning of the calendar year 1933.

PAST AND PRESENT OFFICERS

	PRESIDENT
1932	Wm. H. Weston, Jr.
1933	C. L. Shear
1934	H. S. Jackson
1935	B. O. Dodge
1936	H. M. Fitzpatrick
1937	John Dearness
1938	L. O. Overholts
1939	H. H. Whetzel
1940	D. H. Linder
1941	E. A. Bessey
1942	E. B. Mains
1943	J. N. Couch
1944	G. W. Martin
1945	F. D. Kern
1946	G. B. Cummins
1947	J. A. Stevenson

	VICE-PRESIDENT
1933	G. W. Martin
1934	B. O. Dodge
1935	John Dearness
1936	A. H. R. Buller
1937	L. O. Overholts
1938	E. B. Mains
1939	D. H. Linder
1940	E. A. Bessey
1941	W. H. Snell
1942	J. N. Couch
1943	F. D. Kern
1944	N. E. Stevens
1945	G. B. Cummins
1946	J. A. Stevenson
1947	J. H. Miller

SECRETARY-TREASURER

1932–35	H. M. Fitzpatrick
1936–38	D. H. Linder
1939–41	J. N. Couch
1942–44	G. B. Cummins
1945–47	F. K. Sparrow

COUNCILORS

1932	N. E. Stevens
1932–33	H. S. Jackson
1933–34	C. R. Orton
1934–35	L. O. Overholts
1935–36	C. L. Shear
1936–37	B. O. Dodge
1937–38	H. M. Fitzpatrick
1938–39	W. H. Weston
1939–40	L. O. Overholts
1940–41	H. H. Whetzel
1941–42	F. D. Kern
1942–43	D. H. Linder
1943	F. D. Heald
1943–44	C. W. Dodge
1943–44	E. B. Mains
1944–45	Lee Bonar
1944–45	J. N. Couch
1945	J. A. Stevenson
1945–46	G. W. Martin
1946	J. H. Miller
1946–47	S. M. Zeller
1946–47	F. D. Kern
1947–48	G. B. Cummins
1947–48	J. C. Gilman

EDITORIAL BOARD OF MYCOLOGIA

1933–45	F. J. Seaver, Managing Editor and Editor-in-Chief
1946–	A. H. Smith, Editor-in-Chief
1946–	F. J. Seaver, Managing Editor

1933	H. M. Fitzpatrick
1933–34	J. A. Stevenson
1933–35	F. A. Wolf
1933–36	G. R. Bisby
1933–37	E. B. Mains
1934–38	G. W. Martin
1935–39	J. A. Stevenson
1936–40	F. A. Wolf
1937–41	J. N. Couch (resigned Dec. 1939)
1940–41	F. K. Sparrow
1938–42	S. M. Zeller
1939–43	H. S. Jackson
1940–44	J. A. Stevenson
1941–45	J. H. Miller
1942–46	J. G. Hopkins
1943–47	A. H. Smith
1944–48	W. W. Ray
1945–49	B. O. Dodge
1946–47	S. M. Pady
1946–50	E. K. Cash
1947–51	N. F. Conant

MEMBERSHIP COMMITTEE

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G. D. Darker
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E. B. Mains
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René Pomerleau
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G. F. Weber
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E. W. Mason

Nomenclature Committee

J. A. Stevenson, Chairman
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Committee on Medical Mycology

C. W. Emmons, Chairman
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MYCOLOGICAL SOCIETY OF AMERICA

FINANCIAL STATEMENT

(Jan. 1, 1946–Sept. 30, 1946)[1]

Balance on hand, Dec. 31, 1945:		
Cash	$ 712.40	
Savings account	395.98	
Bonds	840.00	
Total	$1948.38	$1948.38
Receipts:		
Annual dues, back numbers of MYCOLOGIA, reprints	$ 981.86	
Interest, savings account	5.31	
Total	$ 987.17	$ 987.17
Grand total		$2935.55
Expenditures:		
Subscriptions to MYCOLOGIA, back numbers, reprints	$ 787.36	
Printing, addressograph, etc.	156.53	
Letterheads, postage, telephone, etc., for Sec.-Treas.	51.87	
Secretarial assistance	14.63	
Secretary's expenses, St. Louis meetings	69.39	
Letterheads, postage, Editor-in-Chief MYCOLOGIA	53.12	
Editorial assistance	96.00	
Bank charges	1.19	
Total	$1230.09	$1230.09
Balance on hand, Sept. 30, 1946:		
Cash	$ 464.17	
Savings account	401.29	
Bonds	840.00	
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Grand total		$2935.55

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[1] By vote of the Society at the St. Louis Meeting, the fiscal year was changed to Oct. 1–Sept. 30.

MYCOLOGIA

FINANCIAL STATEMENT

(July 1, 1945–June 30, 1946)

Unexpended reserve		$ 3183.51
Current receipts (joint funds):		
Mycological Society of America	$1719.36	
Subscriptions	2813.74	
Sale of back sets (25–)	775.89	
Contributions for excess pages	203.79	
	$5512.78	
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Sale of back sets (1-24) plus index	$ 711.46	
Interest on Endowment Fund	410.00	
	$1121.46	
Total receipts		$ 6634.24
Total on hand		$ 9817.75
Cost of printing and distribution:		
Six issues	$4063.13	
Reprinting exhausted issues	778.00	
Miscellaneous, postage, etc.	193.86	
	$5034.99	$ 5034.99
Balance		$ 4782.76
Transferred to Endowment Fund		1000.00
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The above figures have been officially audited by Price, Waterhouse & Co., and found correct.

(Signed) FRED J. SEAVER,
Managing Editor

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